

8 March, 2000.

Dr. N.V.Joshi
Centre for Ecological Sciences
Indian Institute of Science
Bangalore 560 012

Dear Dr. Joshi,

We have not communicated for a long time. I have been keenly waiting to see the review of Sir Asutosh Mookerjee's Diary in the pages of *Current Science*, but it has not shown up yet. What is the matter? Is it in the pipeline or is it forgotten? It will be sad if it does not get reviewed.

Enclosed is my recent rambling on the internal chemistry of BARC. Being the largest R & D Centre for science and technology, it also holds a major chunk of the Indian scientific community. One of my letters in *Current Science* attracted the attention of Dr. Anil Kakodkar, which ultimately resulted in this essay - in fact more of an introspection than an essay proper.

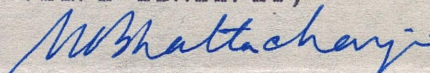
I would be interested in your frank comments. Particularly my interest is to compare its chemistry with that of the rest of the Indian scientific community's.

Professor C.N.^{R.}Rao's editorial in *Science* seems to be a sop to me, probably meant to please the political 'bosses'. May be I am wrong, but what is the majority view? Every one seems to be beating around the bush. I hope many serious scientists are not carried away by the pseudo-patriotism - that is how I view it - of such seniors.

I shall be looking forward to your response eagerly.

With warm regards,

Yours sincerely


S.K. Bhattacharjee

Molecular Biology and Agriculture Division
BARC, Mumbai- 400 085

[Revised]

WHAT BROUGHT US HERE?

(Looking back for some lessons: by an average scientist at BARC)

Like most physicist, I was interested in nuclear fission for what it revealed about basic science, not for what it might have to do with reactors or bombs.

- John Archibald Wheeler in 'Geons, black holes & quantum foams: A life in Physics'.

ABSTRACT

BARC is the largest single R & D organization of our country housing scientists, technologists and supporting staff to deliver promised tangible products of high quality specifically to meet nation's demands, and excellence in basic science of the best of the international quality. Excellence in science and development of high technology were considered interdependent and equally significant for meeting the newer challenges arising out of emerging new concepts and their technological implications globally not only in nuclear energy but in a broad range of fields. So a team spirit between basic scientists and technologists was obligatory. Bhabha's vision, therefore, brought us, the uninitiated scientists and technologists from universities all over the country, under one roof to learn from our seniors and give our best both in science and technology.

The narration is an attempt to look back if we have as scientists or technologists working together in this highly intellectually demanding profession, lived up to those expectations of the society, or even our own as individuals.

What were our dreams? Did we realize them? Have we ever pondered over the past experiences to figure out if we were as individuals, at times, violating the codes essential for healthy team spirit when we failed, or the nature of understanding we received from teammates when the team succeeded in excelling in some complex task? Have we attempted at all, or succeeded in generating a tradition encouraging free thinking and devotion to our profession which upholds the ideals of scientific activity to pass on to the younger generation?

There is much we could have done that we didn't. That is what the narration tries to argue with some suggestions to renew the attempt to bring back those forgotten ideals in our acts and thoughts. It is one individual's reading of the past and a few conclusions drawn from it. Of necessity it is biased. Perhaps if many more come out with their individual opinions to let others know their perceptions, it may be possible to develop a more dynamic community in the near future. This exercise is a necessity we can avoid only at our own peril.

One step forward

BARC, from its very inception, has been the nation's hope for excellence in modern science and technological achievements. International eminence of our earlier contributors emerging from a very modest size of scientific community in the first few decades of this century was a clear pointer to our political leadership that by multiplying this number, we should soon be able to catch up with the West in most fronts. Of course, to be able to visualize the problems associated with scaling up, as we shall soon see, could not have been anticipated. Hope was that those who knew their job well, given sufficient freedom, would be able to keep the quality to the level of the earlier contributors, and deliver the tangible technological benefits to the society as and when required. These expectations permeated the institutions where many of us were being imparted higher education in pure science and engineering. Our concerned teachers, advised us to join BARC, then called Atomic Energy Establishment, and not look for opportunities abroad because Bhabha's ability to ensure high standards in science and technology was never in doubt.

The unprepared mind

Coming from a less known university, I was almost certain of not getting selected. More so because of having learnt a bit about the deep contributions of Indian scientists already in degree and post-graduate physics courses, it did not require any additional grey-matter to realize the limit of my own potential to do good science. I thought of innumerable numerical problems I could not solve or took inordinately long time, conceptual difficulties that needed repeated reading and teacher's help, and the slow pace essentially due to my own inability of taking full advantage of the available school and college education. It was unthinkable that I could ever contribute either singly or in a team which naturally had to have members with brilliant academic records. Clearly, I simply did not stand a chance.

I expressed my apprehensions to those who were pressurizing me to appear for the Training School interview. I was assured that not all scientists whose contributions stood the test of time got their insights overnight, but by sincere hard work and constantly learning from each other. This seemed only a logical possibility since I had not yet seen any scientist at work. Moreover, one of my teachers had pointed out how excellent contributions during European Renaissance and later also in America came from individuals without even any formal education or those with very mediocre performance. For instance, the role model of very bright ones amongst us was Albert Einstein, not known to be particularly bright in student days. So the hope that if I work sufficiently hard constantly learning from others around, I might be able to contribute much better than what my mark sheets would promise to a third person (first two being I and my teacher!), was amply boosted.

Some persuasive arguments

I was also told by my teacher that Bhabha has collected a lot of brilliant scientists and engineers under the same roof and no university in the world can match its intellectual strength. Surrounded by such a galaxy of intellectuals, there was no way that even an average like me would not be able to do something significant in the long run. These assurances seemed hypocritical in the heart of my heart because, at times the associated salary

and position (Class I Officer at the age of about 20 !) were casually mentioned like a prospective bride's qualifications and beauty to a shy would-be-groom in look out for a match. However hypocritic, the pleasure of learning from experiments as in college courses, and seeing the nature's laws pop up beautifully in them was a secret desire that these assurances kept fanning. Nevertheless, it seemed obvious and natural to me that such opportunities in BARC should be available first only to the academically brilliant students. It was not still clear how a mediocre student like me can ever excel. That I thought can happen elsewhere, not in India because nearly the whole of modern science and technologies have arisen and grown there, we are only trying to learn from them¹. Many of our earlier well known scientists and engineers of this and the previous century were taught by European teachers in India and Europe, and had brilliant academic records. Therefore, the argument that even uneducated or mediocre students would be able to contribute significantly as happened often in the West, at least to me, did not appear sufficiently convincing to take the risk even if I got through.

The most persuasive argument, however, was that the Training School provided an opportunity of learning at a very early age from many bright scientists and engineers. The earlier contributors such as Raman, Saha and Visvesvaraya did not get such opportunities and yet they contributed enormously, which we pride. So, it was a foregone conclusion that India would be at the forefronts of science and technology in a matter of few decades. This argument was made with all seriousness and seemed so sound that if we failed to meet that expectation, the blame ultimately had to descend on us individually and each one of us had to do the explaining. We have been given the freedom to organise ourselves without political and bureaucratic interference leaving no excuse of external causes to explain away the intellectual and technological shortfalls from our own set targets. Here, therefore, was a real challenge to the younger generation. In principle, if we so willed and worked with a sense of purpose single mindedly, then success was clearly feasible. If all of us basked in the glory when a team from the establishment achieved some feat, then together we would also share the blame if other targets were not met, or we failed to achieve the excellence in science to the level naturally expected of such a large gathering accumulating bright entrants every year. This spirit will automatically ensure dynamic activity in all fields we undertook to work in and soon we would match the best of the institutions in the world.

This argument was intrinsically so powerful that it induced imagination and dreams, all seemingly logical and realistic. I better not narrate them now to avoid attracting professional curiosity of our psychiatrist colleagues. Unfortunately, in spite of my poor memory in general, I have not forgotten those dreams and, surprisingly, it seems almost as recent as about a year or two back. Perhaps, unaccomplished realistic targets of the dreams originating from intense desires in the formative years chase dreamers till the end.

Two steps backward

Unable to achieve those targets of excellence, we have ultimately taken a pragmatic course: Lower the quality, and the size of the target sufficiently and try to feel at ease with our conscience. If the conscience still continues to prick, indulge in some side activity 'creatively' and be satisfied. Let science take its own course! (Yes, it will. But we will not be counted for anything.) I am sure it will strike a chord in most of our time worn colleagues. It seems our sensibilities did not match the targets, however realistic these targets might have appeared then. We not only did not realize our dreams, we have now generated a

vacuum for a tradition that may soon destroy whatever is left of the team spirit of the yesteryears that some of us have heard, seen and lived with.

What are those obstacles we have created for ourselves? The purpose of this essay is to place my personal thoughts on this aspect of our professional life candidly, without raising finger at any one in particular. It is our joint failure anyway, at least ought to be!

I was taken by surprise, but happy to learn about his concern when, after reading my letter² in *Current Science*, Dr.Kakodkar called me up on telephone to request a write up on what I thought could be discussed within the scientific community of BARC for the benefit of the younger colleagues. A difficult task surely, but an opportunity rare to come by. I could not also resist the temptation to expand its scope to include our mature colleagues, though for quite a different reason. It is largely from the extensive and numerous experiences shared with them that most of my views have evolved. It was also a necessity. These experiences and the underlying lessons, naturally, cannot be excluded from such a narration, for the younger colleagues must know and judge for themselves why as a scientific community we failed to develop a healthy tradition to ensure 'excellence' which many of us dreamt of and were surely within reach.

Up against the wall: The power of self-fulfilling prophecy

It took several years to figure out that one must not only work hard as an individual to realize these dreams, but simultaneously be sensitive to the surrounding in a very conscious manner to correct ones own and others unjust views and decisions - in the interest of the institution itself. For, the future generation will have to be nurtured in an emerging healthy tradition. The mistaken notion I harbored from the start was that such a tradition already exists, when it didn't, and one has to carry out whatever research activity one is involved in, in full earnest, as would happen on joining a Western institution for instance. Bhabha's image of his leadership had promised us that before we joined. It dawned on me much later that even that discipline and enlightened attitude itself had to be generated by us right where we work and, while we work; it cannot be imported by FE payment like expensive equipment! My teacher also did not have the slightest inkling of the fact that I needed to be advised on how a clash of interests while working in a team must be resolved. No, not a single word on that from any one I can remember before I joined BARC.

Only at a fairly advanced age, battered in squabbles of all sorts (and watching many more), in retrospect I realised that on many occasions, I was in the wrong. All along in the past I encountered several fine minds too, but most shut in their own cocoons (see Fig.1), and on the verge of turning cynics or already so. They did not want to assert their authority or persuasive skills when needed even within their own level in hierarchy. They could have very clearly justified such efforts in the interest of the institution. That would have helped new entrants like me correct our attitudes. It did not also take long to see the underlying unstated reason for such timidity: the hope of some goodies for exclusive benefit to the self or to a small but favoured group. The benefit mostly were of material nature concealed at times as reward for professional excellence. More often than not these were a consequence of eroded ethical codes already accepted by the community as something natural, or nibbled a fresh one to set a precedent - and no effective protest by others who could have easily prevented the fall, though some would shamelessly go on to privately criticise it!

The real problem we face is not that of technological or scientific competence to meet any challenge, but that of pulling ourselves out of the vicious cycle we have entered by our own attitudes. The mechanism sustaining this state is well described by a law in sociology: 'The law of self-fulfilling prophecy'. The law originally described why the Blacks in USA did not succeed like Whites: Blacks have poor IQ, so they should be prevented from competing. Their IQ does not improve as a consequence of this block. It leaves them where they were, unable to compete later if an opportunity is given, thereby proving the truth of the law.

The all-pervasive cynicism steps in wherever a strong stand must be taken to correct even an obviously wrong decision for the fear of either being marked as anti-establishment which might jeopardise the career prospects, or that of getting involved in endless squabbles in the absence of a sensitive scientific community that can be relied on for quick and fair opinion to put an end to the squabble. Almost on all occasions when a corrective action was needed from members in this community, I was politely told that if it does not affect my personal interest, why bother? Nothing will be done by the protests or private counseling of appropriate authority even if it is reasonable because so-and-so at higher level is protecting so-and-so ! And, truly, nothing happened as they would gleefully point out later, thereby establishing the truth of the law. It is clearly an escapist argument and is dished out by individuals at every level including Group Directors. It somehow does not occur to most that nothing happens simply because we, the individuals, do not intervene in time. So the negative regulation is complete and tight from top to bottom, the new entrants will anyhow learn to react in the same manner soon enough to keep up this stinking tradition if perchance they were not already soaked in it before entry, and that would be rare as I argue below.

Origin of our cynicism

Not surprisingly, therefore, most of us do not care to act, knowing very well that the act will lead to maintaining better conditions of work in the institution, until it threatens to affect our own selfish immediate interests. Then we tend to react impulsively, grumble on, and without considering the deeper implications, take recourse to unethical means to regain the lost ground or even try to fish in troubled waters instead of helping the situation in a positive manner. Therefore, in either case the institution's interests are compromised - the persisting stink gives license to commit the next violation. Perhaps it is one most detestable attitude we have inherited from the past as people, at home with a chalta-hai culture and, at times even conceited enough to claim misplaced tolerance as some kind of spiritual virtue. This trait in us, though in a very different context, was vividly portrayed by the well known writer, V.S.Naipaul in *India: A wounded civilization*. He narrates the experience of walking through a slum that was being face-lifted by the organised efforts of some motivated persons amongst the settlers:

There were eight committees, and it had first seemed too many for that small settlement. But eight were apparently not enough. There were some sections of the settlement where for various reasons - perhaps internal political reasons, perhaps a clash of personalities, or perhaps simply of absence of concerned young men - there were as yet no committees. Through these sections we walked without speaking, picking our way between squirts and butts and twists of human excrement. It was unclean to

clean; it was unclean even to notice. It was the business of the sweepers to remove excrement, and until the sweepers came, people were content to live in the midst of their own excrement.

Obviously, the trait of leaving to others the dirty task of cleaning filth around us is so innate that, unless we are on guard, and in spite of the zeal to reform, it is bound to adversely affect functioning even in our professional activities. If we are prepared to sincerely acknowledge vulnerability to this trait perhaps we should not take it to heart if someone, irrespective of the position in the hierarchy, happens to notice a related lapse in our action or decision and is kind enough to caution us. Nor should we hesitate to point out politely to others, explaining our reasons for thinking so, if they happen to overlook this pitfall in their acts. On many occasions the caution may be heeded even if unacknowledged, and however small, that would be a *real gain*. Someone has to clean. Surely it won't be an imported sweeper. If outsiders help us clean, they would also like to rule over us. Haven't we learnt that recently?

In my view, we are usually not aware that the indifferent attitude towards our own environment or unethical behaviors were learnt from childhood. It naturally leads to apathy which, presumably, forces a cynical outlook in most when we fail to correct matters of serious concern arising later in life. This hinders our institutions from turning dynamic and efficient. We, somehow and sluggishly continue to face challenges and, quite understandably, fall behind when creativity tied to team spirit is demanded. Being intrinsically no inferior to others in our intellect individually, we still contribute, but only extremely inefficiently.

Surely going against innate nature which controls our behavior unconsciously and impulsively, is the most difficult exercise, perhaps, incomparably more difficult than solving the professional technical ones. More so at an advanced age in spite of accumulation of enormous experience because we may not have cared to introspect and learn after the occurrence of events where the judgements may have gone wrong. The younger colleagues need to be conscious of such lapses, if they wish to function in a more professionally satisfying and stimulating environment tomorrow.

Lack of team spirit

Though most of us have not cared to acknowledge our critical weakness mentioned above, I did meet a few who seemed quite conscious of it. This gave hope that there must be many more had I looked for them. At one stage, therefore, I wished to work for BARCOA that could provide a grand platform to get such people talk their minds freely and debate issues in internal conflicts which needed dispassionate resolution. Very soon I realised that even this platform was bugged by the same problem. Here too it was not possible to iron out differences of opinion in a responsible manner that was symptomatic of missing team spirit, and possibly also because constraints were fewer than while working as a teammate in professional activity of the establishment.

Thus BARCOA remained labeled unfairly as the last resort of unreasonable anti-establishment protesters, though BARC itself had accumulated probably a much larger fraction of cynics and manipulators. Indeed many otherwise reasonable individuals, though gracefully not all I happen to talk to, explained to me that unless one is manipulative and 'chamcha' of their superiors, one cannot rise in position in BARC. As a blanket statement

it was a bit too hard to swallow because it left open the possibility that the commentators who would more often be a non-sympathiser of BARCOA, knew the rules of the game but lost the race at some stage. How could such private charges be accepted as a matter of faith? Reason in our teams in any context, BARCOA or otherwise, very often gives way to unrestrained emotions leading finally to either timidity or aggressiveness amongst us. The need for a balance is lost sight of in most events.

However, it cannot be contested that in some cases at least similar charges were definitely correct. Manipulations seem to be rewarded, perhaps out of ignorance of the concerned authorities about the underlying realities at times, by bestowing more power or other perks to obviously undeserving individuals. Acts like these have been fatal to team spirits necessary for institution's health. Such damages are unlikely to be prevented in the future too unless we are alert to check before they occur.

Team spirit: a complex concept in the context of BARC

A question of extreme importance has cropped up in recent years in BARC which must be attended to urgently because its non-resolution will most certainly cause long term damage to the establishment. There is a distinct possibility of drying up of whatever team spirit exists in heterogeneous working groups of scientists and engineers today, a sinister fissure developing due to shifting perceptions of technologists about the role of basic scientists, and pure science itself.

It may be useful to first discuss at some length the meaning of the phrase 'basic science'. I have found that many technologists like engineers of nearly all disciplines, food technologists, and even some biotechnologists use the phrase to mean something very different from what those claiming to be doing research in pure sciences imply.

Technologist's view of basic research

Dr. Kakodkar's first transparency highlighting that basic science is essential for technological progress was, therefore, a very significant and welcome statement made in his recent talk on 'R & D for Nuclear Power in the Coming Decade' in the IPAS-99 seminar on 'Physics in 20th Century and Emerging Trends for the New Millennium' at TIFR organised by IPA. Nevertheless, the notion elaborated in the talk matched the perception of the other technologists I had heard earlier in private talks. In the following I will discuss the two points of view as I understand, using specifically the context of the advanced power reactor design from his talk by way of a concrete example for convenience.

Dr. Kakodkar emphasised that basic science would be needed for the Thorium cycle based reactors to be developed and data such as nuclear cross-section of some elements appropriate for the advanced reactor designs will have to be obtained by scientists. This is clearly a case of technology directed basic research.

From a technologist's point of view this surely is basic science since such studies will generate 'basic' data for reactor design purposes, or other technological targets and, therefore, use of the word 'basic' in such context is natural. However, what fundamental researchers mean is altogether different which subsumes technologists' view, and is more extensive as I discuss below.

Let us take a hypothetical example of data on nuclear cross-section of an atom of interest to the reactor designer. This data, we assume, is of interest to a theoretical physicist

too. Technologist may be happy with the data determined with certain accuracy, say more than 0.1%. Assume that an accuracy of more than 0.01% is over specification for the design. An experimental scientist associated with the theoretical physicist, however, may be required to meet a target of 0.001% accuracy to falsify competing hypotheses proposed in which a particular nuclear interaction involving the same atom enters in some way that requires the value of the same cross-section to be fed amongst values of other parameters for calculation. The values of these parameters to the required level of accuracy, we assume again, are well established and freely available in the literature.

Assured of 0.001% accuracy, the theoretical physicist would be able to eliminate all except one hypothesis³, thereby establishing one model of the proposed mechanism in the interaction. This knowledge may be crucial in changing our view of the reality in a minor or in a revolutionary manner depending upon the context in which the question was addressed by the theoretical group. It could be related to a cosmological, particle physics or a quantum mechanical problem.

Therefore, the fundamental research group may need to spend more money and effort in obtaining the same nuclear-cross section data than the technologist may consider necessary for the promised *tangible* reactor the like of which the theoretician simply cannot promise. On the other hand, and this is vital to mutual respect and understanding, the theoretician's *intangible* solution is an expectation from the scientific community globally in the sense that some other workers may be looking for the solution in relation to their fundamental or applied research activities, most of them being likely to be engaged in solving problems very different from that of our hypothetical theoretician. It is entirely possible - history of science will bear a witness - that such data could point to a technology of the future which may not have been anticipated until the theoretical insight withstood the test. That test could not have been possible with 0.1% accuracy which was considered adequate for reactor design. It should be appreciated that an unanticipated viable technology in the future may need to use the precision data just as a proven technology today uses the cumulative data published by the fundamental researchers in the past.

Restrictions are intrinsic to technological developments

Understandably, legitimate constraints imposed by the demands of a preconceived and feasible technological target will generally restrict the freedom of the mind to look at any problem in a way such as fundamental research may demand, or permit exploration stimulated by an intuitive hunch or guess work⁴ - a process that is known to play a vital role in making advances in basic research. Sometimes, though infrequently, a fundamental researcher may even bump into a situation challenging the currently accepted conceptual framework at the cutting edge of knowledge in pure sciences. Such a possibility and its impact, forcing more or less revolutionary change generated by a crisis in our understanding, lurks in the minds of scientists engaged in fundamental research. Normal science, however, is always directed at fitting the data in the currently accepted paradigm which Thomas Kuhn describes as 'puzzle solving' exercise⁵.

Confronted with a situation defying solution by known techniques or conceptual framework in the concerned field, at times scientists use knowledge from widely different areas some of which may appear even irrelevant to others. In contrast, and quite naturally, from the point of view of professional requirements, the application oriented scientists or

technologists would probably very rarely, if ever, need to be exposed in a comparable manner.

If answer to a deeper question becomes obligatory, a technology would be rightly considered non feasible, and the problem would then fall in the realm of fundamental research. The tackling of such problems is generally extraneous to committed technologists. The solutions to such problems, though obvious but not sufficiently appreciated, require total freedom of the mind to evolve strategies with a complex mix of theoretical and experimental skills uniquely for each problem, and almost in all cases target dates cannot be promised. Technologists, evidently, cannot depend on such basic science for their targets, though such data are of immense importance to the fundamental researchers. Here is an illuminating folly to reckon: Reagan failed to achieve the results from his proclaimed mission to cure cancer in a decade for which he granted enormous financial support. The misadventure was inspired by the successful landing on Moon accomplished in the earlier decade. The wrong inference drawn from the success was that given sufficient support a technological advance can be targeted without solving the associated fundamental problems. However, this folly turned out a blessing in disguise because it advanced fundamental research in biology in considerable depth, indirectly supporting the broader field of biotechnology whose potential applications, as is common knowledge, are not confined to medicine alone.

The nature of contribution in basic science and team spirit

Fundamental research could be highly specialised and pursued by very few groups or individuals in globally scattered labs. However, the crucial factor is that the legitimacy of an effort of a basic scientist is provided by the general authority of scientific opinion through peer reviewing. *Every scientist working singly or as a member of a group is expected to relate the specific problem at hand and the findings logically to a body of knowledge which is growing without any rigidly projected plan.* And unlike in technological developments or applied research, innumerable laboratories involved in equally deep and specialised problems simultaneously contribute to the growth of this knowledge superstructure. It is in this very important sense a team work, though not consciously recognised by several otherwise capable Indian scientists, and is not limited by local or geographical boundaries.

Scientists weave a perpetually growing nest of knowledge

It should be easy to appreciate now why the findings of two disparate groups of scientists may not be directly used by each other but, like a pair of well separated tiny and rickety twigs enmeshed in a bird's nest, form supports of the emerging superstructure of knowledge which grows as though a robust nest in the making. It is from this growing nest as it were, the new technologies are born spontaneously, usually without any prior design. *Scientists sense the form of the knowledge they seem to be targeting at, perhaps, no clearer than a bird's knowledge of the shape and the specifications of the nest she is weaving.*

It is indeed unfortunate that Indian scientists abhor referring to each other unlike their Western counterparts who are no doubt highly critical, but value and recognise their works in print, as an open and yet tightly knit scientific community - a virtual team in a perpetual state of flux. In contrast, our attitude, probably driven by a desire to be

exclusively recognised by the Western community, apart from giving a wrong signal about the worth of our own work, hinders the emergence of a visibly dynamic scientific community that is so vital to attract bright students intending a research career abroad; many bright ones land up in more mediocre research groups than available to them in India.

Excellence cannot be bought; demands protection of scientific ideals by the scientific community as a whole

In my view, the desire to please a scientific opinion (of the West) has degraded the quality of basic science at BARC and also the rest of our country. It is clearly noticeable now that we are more than about half a century away from some of our best contributions in basic science. This vulnerability, interestingly, was first noticed within the scientific community of the West. I quote Michael Polany from his lecture on 'Authority and Conscience' delivered in 1946. He was warning basic scientists not to please the Academicians or superiors in otherwise well run Government organizations who were dictating scientific problems to mature scientists:

A community of scientists in which each would act only with an eye to please scientific opinion would find no scientific opinion to please. Only if scientists remain loyal to scientific ideals rather than try to achieve success with their fellow scientists can they form a community which will uphold these ideals. The discipline required to regulate the activities of scientists cannot be maintained by mere conformity to actual demands of scientific opinion, but requires the support of moral conviction, stemming from devotion to science and prepared to operate independently of existing scientific opinion.

We have slipped somewhere along the way. Or perhaps we never thought that there are ideals to uphold while learning the substance of modern science from the West which should at the same time teach us not to please any particular scientific opinion including that of the West itself. Until we recognise the power of these ideals and uphold them in our acts, professional activities of Indian scientific community will not cross or even reach the level close to that of the global best. *We might excel in a few fields for some time by some happy chance, but will remain essentially erratic and, at any given time, limited to fewer fields than we may have planned for and invested our resources with high expectations of returns.*

The high-tech programmes as well as pure science research have come under criticism in several quarters as an expenditure that has become socially irrelevant because the benefit do not flow to masses. This assessment by well-meaning critics suffers from a serious misunderstanding. I have no doubt, however, that the apparent irrelevance is a consequence of mediocrity, largely due to our inability to uphold scientific ideals.

What is not appreciated by the critics is that the lack of scientific ideals would also not give the expected results from our efforts to focus on such programmes which are drawn up to meet the minimum basic needs of the common persons. This is because mediocrity and, therefore, all the ills resulting from the currently practiced eroded ethical codes in Indian scientific community will be more easily justified, and help evade accountability of massive expenditures by the managers of such programmes than, perhaps, by those managing high-tech

or pure science research who must show easily identifiable tangible products in promised time, or recognition of scientific excellence by the international peers.

'Basic science' label can be misused to escape accountability

In applied research directed by the demands of tangible deliverables, excessive freedom in the pretext of basic research can be a nuisance in meeting the deadline of promised technological targets. BARC has been a victim of this confusion in the past. Those who demand resources for applied research can easily hide behind 'basic research' when targets are not met, because most technologists unaware of the essential difference may equate it with fundamental research not directed by any application goal. The blame may easily land at the doorsteps of also those who are committed to fundamental research. They uncomfortably and unjustly find themselves now clubbed with application oriented basic researchers for relative assessment when tangible outputs were not their targets to begin with.

The fear of being misjudged has led many good basic researchers to switch over⁶ to some applied programs patently under a misconstrued pretext of 'relevance'. For, they are either not aware, or find it convenient under pressure to ignore the fact that excellence in fundamental research is just as much relevant here at BARC and, in its own interest, should continue to be so. But there is a killer factor not explicitly recognised at least in BARC that results in avoidable confusion in relative assessments which perpetrates undefendable servitude. It also gives an easy handle to those who would not like to undertake the hard work in reaching a level of excellence to be recognised by the peers as significant contribution in basic research.

A killer takes its toll in fundamental research

Put simply, it is the non recognition of fundamental researchers' efforts by peers if they lagged behind in publishing their findings. Such efforts will eventually not be remembered by the scientific community except perhaps by historian of science who, by some rare chance, may be interested in the origin of the idea concerned at a later date, if at all. They must compete globally and publish first to be recognised. Moreover, there is no guarantee that publishing a new finding first will necessarily be remembered for long. In basic science overthrowing of past data, or a novel idea, even after it may have set others thinking differently in their own problems, unless it is essential directly for the subsequent growth of knowledge, is a norm. The deeper contributions naturally get more attention and stay longer in the memory, but at times ignored to be recognised or rediscovered much later.

To appreciate the kind of risks a basic researcher takes, one has to imagine what we would have lost had the Russian scientist Mendelshtam published his work first in *Nature*. *Raman-effect* would then be known as *Mendelshtam-effect*. Not many know that Mendelshtam had also discovered the phenomenon about the same time and, apparently, Europeans referred to the phenomenon for some years as *Raman-Mendelshtam scattering*⁷. He is forgotten like so many others in the past having fallen a prey to this killer enchantress.

The tragedy is that though everyone faces the same obstacles of infrastructural, bureaucratic and administrative inefficiency, the delays in meeting the promised technological targets, unless excessive, are patronisingly ignored by all, and the achievements praised by

the nation, obviously, for its utility. But the delay of even a week in case of fundamental contribution is not only ignored by the peers, it also cannot attract any user the way a second rate tangible technological product could. No basic scientist grudges this, except perhaps those who have not given a thought to how knowledge in basic science grows. Basic scientists highly value this old tradition which may be viewed, perhaps with a bit of imagination, as a sort of team spirit of the global scientific community.

Unfortunately, the fundamental researchers are accused of being inefficient and mediocre in comparison to that of technologists which is evident from the generally acknowledged differential speed of career growth at BARC. A scientist has to swallow this ignominy too and go on to try to do a quicker job of the next not so much for career as for appreciation from the peers. This has to be done in the absence of sufficient understanding from even most of the close colleagues, for, our sensibilities do not yet match the professional attitude necessary to maintain a stimulating environment particularly for basic science in the Indian context. That must change for BARC's health and spirit.

We must accept the blame of mediocrity and failures

It will be unethical not to take the larger chunk of the blame of delays in achieving technological targets, or the failure to excel in fundamental research by the scientific community of BARC and pass the buck entirely to the inefficiencies in some of our services mentioned earlier. Our own professional mediocrity is apparent to a dispassionate observer. In my personal judgement it is clearly visible at least in the area of fundamental research.

Mediocrity weighs more heavily in basic research than in technological achievements because the results of the former will have to be produced at a speed comparable to that in the international scientific community, which means the best of global competitors, not that of the Indian alone. But for the technologists, it is not a decisive factor because the results can be, and usually are, developed decades after they have been demonstrated elsewhere. Moreover, the quality of the products of technological output do not always have to match the international level so long as they are tolerably functional and acceptable to the users, but for a fundamental researcher there is no room for such mercy. Any sincere investigator will be embarrassed if a praise is bestowed on him/her by sympathisers who may extoll a fundamental work, essential aspects of which has been reported earlier. When members of a research group look forward to receiving appreciation on such efforts as scientific excellence, it should be inferred that the group has given up the race to excel for some reason and would still like to reap undue benefits of career advancement.

It is essential that we learn to admit our failures and suffer the consequences without falling in the grip of a sense of alienation. Scientific opinion must assert this value decisively and frustrate every attempt across the hierarchy to violate this most critical of all ethical codes of the profession. There simply is no shortcut to bypass this hard way. Only such attitudes will give the right signals to younger colleagues: *Earn your reputation by devotion and achieving, not by unfair means.*

Assessing basic research

The different nature of fundamental research as described earlier would also explain why the conventional management techniques in an honest attempt to evaluate the output, will not succeed. It can only mislead an honest inquirer unfamiliar with the process of conducting basic research, when trying to understand the significance of the work or the extent of progress made by any group.

It is for the same reason again that the precise quality and the extent of progress in fundamental research can be judged best by the appropriately chosen peers alone. Moreover, unlike in technological or applied projects, the judgement by peers at times, even with all good intentions, can go wrong in the case of fundamental research. No serious scientist would take such a damaging judgement to heart for long, if no obviously extraneous factor was perceived to have influenced the opinion. Anyone aware of the history of scientific ideas would know this, even though one may be uncertain about the possible outcome in a particular case until it is resurrected at a later time by others. But this risk of being ignored indefinitely even after contributing significantly is clearly there which the technologists usually do not face. Mendel's law of inheritance which paved the way for modern state of biotechnology, for instance, was resurrected 30 years after the reported discovery!

Cause of mediocrity in basic science

It follows from the nature of assessing mechanism that a mediocre effort in fundamental research would be judged so by the lack of depth and/or imagination of the scientist by the peers in the same or closely related fields. Amassing data mechanically without appreciating its worth in relation to the general body of scientific knowledge is quite frequently considered good science erroneously, though 'data' itself is at the heart of basic science. Such efforts do not lead to progress in science and are wasteful. Therefore, if the peers in a scientific community are mediocre and unable to distinguish between good and bad science, the scientific contributions, by and large, will be mediocre too irrespective of whether the contribution was from an university or a National laboratory. The laboratories with enlightened scientists can resist the decline by choosing peers exclusively from more or equally dynamic laboratories, and giving full respect to their opinions, but these are too few in India in most disciplines. Indian science is an unfortunate victim of this ailment because our peers have gradually relaxed their standards in marking 'excellence' for various reasons, some of which are clearly unethical, to a very low level even compared to what existed within the Indian scientific community during the first few decades of this century. Less than forty years ago J.B.S.Haldane, the well known British geneticist settled in India, noted our weakness which he thought led to our incompetence⁸:

The root cause of all this incompetence is not far to seek. A large number of Indian scientists have no pride in their profession, though they are proud of their salaries and positions. The opposite is true in Europe, as it was in ancient India.

This erosion of value - *pride in the profession* - has naturally created a larger fraction of mediocre amongst the modern peers lowering the average quality of basic science in India.

It is significant and also extremely disturbing that no serious debate followed this observation by one of the giants in basic sciences who made India his home, and surely had no reason to be biased against the Indian scientists. We cannot escape the conclusion that those who were young and future leaders of the Indian scientific community amongst them did not pay heed to Haldane's warning. Now fully entrenched in mediocrity, our aging seers may be alarmed, though many do not have the courage to admit it publicly. Can they really undo now their past negligence which probably is the primary cause of our mediocrity? Perhaps they could help by interjecting sensible comments and anecdotes to the currently on going debate on the quality of research and higher education in the country, and *not use their power to silence the responsible critical opinions, particularly from the younger colleagues.*

B.A.R.C.'s problems

Some of the more significant specific reasons leading to the relaxation of standards at BARC for judging excellence deserve our serious attention.

We have not cared to distinguish clearly between applied research with a declared concrete goal and basic research with a set of fundamental questions to answer. That leads to a license for explaining away failure to meet the concrete promised target by showing a few publications at best. Fundamental researcher too can get away with poor level of research by producing a large number of papers in second rate or at times even obscure journals of which there is no shortage these days. The effort to improve the quality of basic research would appear a stupid exercise if peers called to judge the work are not sufficiently knowledgeable, or the views of the knowledgeable ones are overruled by the non experts for whatever reasons. The consequence is a dangerous wrong signal: Do not undertake any challenging problem if you wish a smooth career.

We de-motivate direct recruits even with excellent track records simply because the official label of 'Training School' is good enough to condone the shortfalls in quality or quantity of others work. This differential needs to be eliminated after the initial grade fixation has been done to both categories. The subsequent career growth should depend blindly on the merit of the contributions alone. Marginalisation of direct entrants leads to several serious problems: Firstly, we cannot get the best out of them and teach the juniors the skills imported through them. The environment stinks of a modern version of caste system already. Secondly, the inbreeding leads inevitably to gradual erosion of the quality of technical knowledge and also lowers its growth in general. This ensures perpetuation of mediocrity. Thirdly, teams with mixed members cannot sustain for long a stimulating atmosphere and a team spirit of high order.

We need a free and fearless, but responsible debate

It will be preposterous to assume that any single individual irrespective of the experience and the position in the hierarchy can visualize '*The*' route for all to follow. Nor is it evident that there must be a rigid and unique route that may be found handy for the future indefinitely. What then is the way to reach a reasonable consensus on these issues at least for the foreseeable future? I suggest the following as the first step.

In any elite scientific community members must enjoy academic freedom. The general authority of scientific opinion takes care of the attitudes of its members. And only when the members respect this authority, they will be found to behave with restraint in the interest of the institution. *The faith in sincerity of the other members in the community is the underlying assumption.* It is through responsible debate alone when members of the community feel obliged to openly discuss the ethical issues under question in their real or apparently aberrant decisions that these issues would be sorted out without any sense of fear. Those who can affect the careers of others should give clear signals by their behavior, seen through consistency of how they act and what they state in such issues where they take any particular decision to set things right in the interest of the institution.

It must be realised that any one in the hierarchy is liable to be just as much a victim as a perpetrator of unethical behavior inimical to the interest of the organization. Just as a lower position in hierarchy does not imply a vulnerability to victimization, a higher position does not automatically guarantee immunity from accountability to the scientific community. And the converse is true as well simply because all must enjoy equal rights to be supported by the scientific opinion of the community through such open debate.

In essence, the fear of accountability through open debate will gradually instil in us a responsible behavior at all levels, and that is what we need first. We shall then taste the academic freedom without any strings or fear, and at the same time inculcate a sense of responsibility which cannot be induced by codes laid down in the official books on Conduct Rules. Haven't we enough brains to violate nearly every one of them in the books if we are really up to that, and coolly walk away untouched by law?

Shall we dream and work to realize it once again?

In the present climate all of us are losers intellectually. No wonder BARC's image depends only on tangible outputs which have been demonstrated earlier elsewhere (what a pity for basic researchers!), and in order to get more of it the real significance of basic research is vanishing from our minds. This will certainly have its repercussions on the technological front sooner or later because inbreeding will neither give birth to novel sophisticated technologies, nor find good basic researchers ready to quickly develop those which may have appeared elsewhere but are protected by patents. We may then be compelled to stoop down to adopting dubious means as some countries are forced today.

In order to ensure the best in the future, we need to show the best soon to the society and attract those youngsters who wish to excel both in fundamental research and in technological skills in nothing less than global competition. That was Bhabha's vision and the nation supported it all along with a large heart in spite of abject poverty. Our vision has to be at least comparable and not just tolerate infusion of newer blood through experts from all over the globe, but give them the respect they deserve for their knowledge, something we have not cared to do in the past.

I am aware that my friends here can list a lot of achievements to our credit from the past. But can we really match the contributions of those who left our company early to learn more elsewhere and excelled in the meanwhile? I have always, without a single exception who among others gave a talk here, found these old friends' and even recent students' achievements far above our current quality and wondered, was it a mistake that I did not leave this organization like them? *Can we try to pull ourselves up to prove that, no, those who stayed back did not commit a mistake after all?*

REFERENCES AND NOTES

1. The Western intellectual tradition is stronger than ours because they do not need a soothing balm to heal their bruised egos when drawing upon other civilizations for progressive ideas, they simply learn paying due respect to the sources. So the Greek's contributions are openly acknowledged copiously as the stimulus for modern science and technology. One should watch the famous serial 'COSMOS' by Carl Sagan to appreciate how deeply and sincerely a Western scientist feels and expresses the community's debt to ancient Greek scholars. We acknowledge Western contribution only grudgingly, and are constantly on the lookout for some hole to gloat over our past contributions even without having read them carefully. Only when we free ourselves from such inhibitions and pump in whatever is still useful from our past achievements along with those from others, shall we be able to compete globally and enrich our cultural heritage for our descendents.
2. Bhattacharjee, S.K. *Need to vitalise, not preserve, India's culture and environment. Current Science*, 1999, 76, 119-121.
3. Popper, Karl R., in *The Logic of Scientific Discovery*, second edition, Harper Torchbooks, 1968.
4. Kuhn, Thomas S., in *The structure of Scientific Revolution*, second edition, The University of Chicago Press, 1970.
4. Kuhn, Thomas S., in *The Essential Tension: Selected Studies in Scientific Tradition and Change*, The University of Chicago Press, 1977.
6. Such switching from basic to applied research is laudable only in a case where option was available to choose without a carrot or stick, which would have ensured that the interest was genuine. Otherwise it is a significant loss because someone having matured in basic science for a considerable period would not be able to make use of his deeper knowledge and expertise to full advantage elsewhere except, perhaps, in rare cases. Redeployment in such cases is going to be counter productive for the institution in the long run.
7. I learnt this from my physics teacher, Shri.S.C.Mookerjee.
8. Haldane, J.B.S. *What ails Indian science?* reproduced in *Current Science*, 1999, 77, 305-307.

ACKNOWLEDGEMENT: The entire community of BARC and its metabolic activities for the past thirty five years. I am thankful to Jyoti Ramchandani and Shalaka Metkar for critically going through this revised version. Thanks are due to Arun Das, ex-BARC employee, for redrawing the cartoon (Fig. 1) some fifteen years ago from *The Indian Express*.

AUTHOR:

S.K.Bhattacharjee
Molecular Biology and Agriculture Division
BARC
Mumbai - 400 085, India

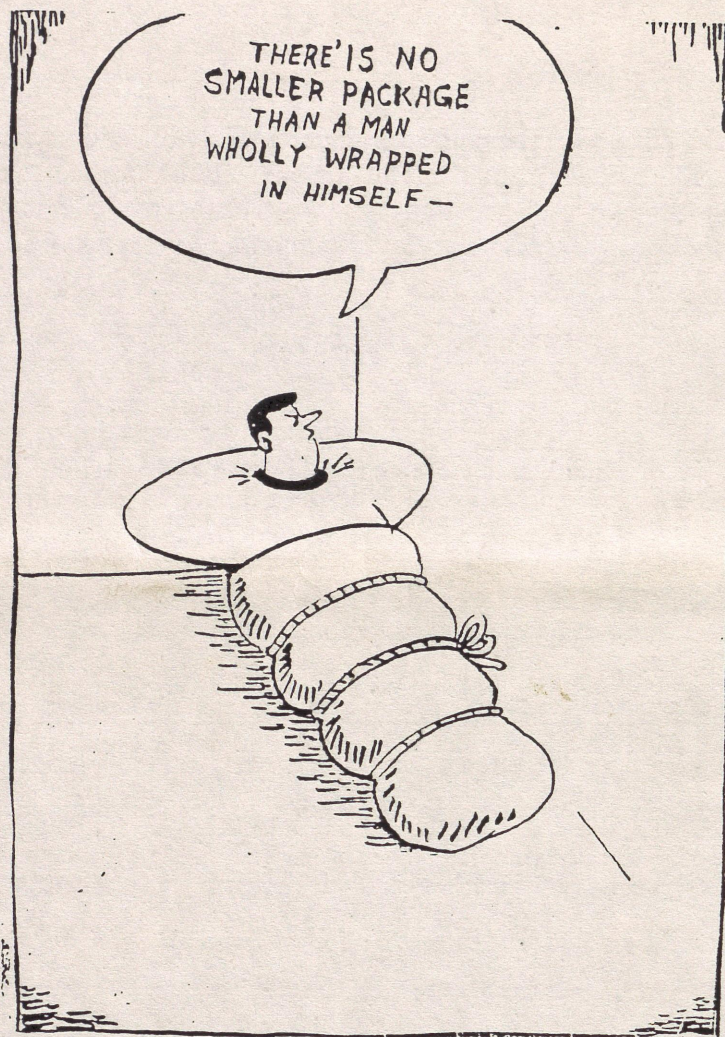


Figure 1.

Individuals are important. Individual's understanding of his/her role in a team is important. Hence individuals are important as individuals even in a team.

Team spirit refers to individual's sensitivity towards others expectation from him/her in achieving an agreed upon goal. So, once again individual is important.

In a team, every individual is important. There is nothing like a team spirit existing in vacuum, detached from the minds of the teammates. Teammates are individuals. Hence every individual in a team has a mind somewhat different in having *something additional*, and not subtracted from the mind of an individual who exists as an isolated being.