

TALK DELIVERED AT

YISC

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Prof. Barma, Prof. Gurjar, Distinguished Guests, and Ladies and Gentlemen,

At the outset, I would like to profusely thank TIFR, in particular Director Barma and Prof. Grover, for dragging me out of obscurity and bringing me over here. As I look at the distinguished audience assembled in front of me, it really seems like a dream. Compared to the talent present here, I have done little that I can boast of. At the same time, I do not want you to judge my entire generation on the basis of the feeble sample you now see speaking to you.

We had our own stalwarts, who like hardy pioneers, worked hard and sincerely all the time, made important and indeed significant contributions, and yet received little recognition because they preferred to maintain a low profile. I am therefore particularly delighted to see in this distinguished gathering two veterans from my time, who by their very presence would make it abundantly clear that our generation too had its great achievers. Please would you join me in giving a big hand to Prof. R. Srinivasan and Prof. Mukunda, who, by the way, spent many years here in this very institute before he moved over to Bangalore?

Compared to the two gentlemen I just mentioned, Destiny pushed me into an incredibly wide spectrum of activities which, at the end of the day, left me with a pretty anaemic resume. Fortunately, bureaucrats do not evaluate performance and that is how I managed to retire with full pension! If at all I can make any claim, it would be that I, along with many others of my generation, offered our shoulders so that you can stand tall and look much farther than we were able to. But even what little we did was possible because way back, one man decided to stand tall on his own, without the need for anyone else's shoulders. Today, I feel proud to join all of you in paying tribute to this great son of India, Homi Bhabha, who not only made this magnificent Institute possible,

but also for all of you young scientists to assemble here, on the strength of your own personal accomplishments and achievements.

Since I have already written a small scientific biography of Bhabha, I shall not cover that ground again this morning. At the same time, I cannot help recalling that way back in July 1955, when I first came to this site to work, all that existed were a dozen or so dilapidated naval barracks of World War II vintage, with roofs that leaked like crazy during the monsoon, and rooms filled with all the war junk one could wish for. Thus, our experiments were done largely with equipment built out of war junk, but we hope it was not junk science!

A few words now about Homi Bhabha, before I start reflecting on whether his work and legacy have any relevance and meaning for the future. Bhabha really got going in 1944. At that time, he was in Bangalore, trapped in India by World War II, and doing his best, almost single-handed, in the Indian Institute of Science. It was clear that the war was coming to a close, and the question Bhabha faced was whether he should return to the West or stay back. He chose to stay back and did it in such a manner that he never had to cry or shed tears about having made a terrible mistake. So, the first quality that strikes one is his guts, his toughness, and his courage; he was never a whiner. If something was lacking, he did not complain; he just went ahead and got what he wanted; and that's exactly what enterprise and guts are all about.

Next, I must commend Bhabha's amazing and extra-ordinary vision. He came to India trained as a theoretical physicist, and with a private passion for pure mathematics. Add to that his taste in music, art and culture, and you get a person who could not be more sophisticated, westernised and thoroughbred. He had everything a snob would want, but that was the last thing he was. Yes, he could be arrogant and haughty when he wanted, but when it came to hunting for talent, he had no hang-ups or barriers. On top of that, cast in the mould of Leonardo, Bhabha never hesitated to look beyond Physics into not only other branches of science, into not only technology and industry, but even into such things as gardens and, believe it or not, designing sets for dramas.

Today, almost everyone knows that Bhabha was the founder of TIFR and of the Atomic Energy Program in India, but how many know that he it was who also laid the seeds for our by now quite respectable Space Program? And not many of you might be aware that immediately after this country performed miserably in 1962 when the Chinese invaded India and came all the way to the plains in Assam, Bhabha began to

worry about the deplorable state of our electronics. On his own, he started preparing a report for propelling India into the Electronics and Communication Age, but unfortunately, he died before he could complete that task; and that was one of the worst things that could have happened to this country. At that time, semi-conductor electronics was in a rather primitive state. If only we had made a strong entry then, we would have not have been too far behind America. In fact, Japan was just beginning to stir and barely heard of, in the world of electronics, that is. But then you know about the Japanese; once they make up their mind, they do not waste a moment. Instead, they work hard and in a highly co-operative manner, and in a few years you suddenly find they are everywhere. They surely know how to go places.

As for this country, unfortunately for us Destiny had other plans and took Homi away from the scene in the mid sixties, challenging us to develop electronics **without** the help of Bhabha. That of course the country failed to do, because there was none like him to take on such big challenges, starting from a scratch.

Many are the achievements of Homi Bhabha and I am sure a lot would be heard about that throughout the year during the many functions that would be held in his honour. However, there is one important contribution of his that I doubt would ever get reflected in all that tribute, and that relates to the very last speech he gave in this very Institute, shortly before he left on what was to be literally, his very last journey. I am here alluding to a speech he delivered to the International Council of Scientific Unions, a body to which he was playing host then.

The public is blissfully unaware that Indian scientists are literally divided into two separate universes. One universe consists of institutions like the TIFR [thank God there are still some like that] where bureaucracy is relatively harmless. But there is another universe with labs like those in DRDO, where finance officers literally hold all the levers of power and authority in their hands. This is not the place to discourse on that painful topic but the fact of the matter is that way back in the late fifties, no less a person than Homi Bhabha himself had to face strong bureaucratic obstacles, and that is why he took it upon himself to deliver an important talk on that critical subject.

The problem not only continues to exist but has in fact become aggravated, and the sooner something is done about it the better. I do not know who would be bothered about belling the cat, but I shall cite two small examples from the experience of Megnad Saha, going back to the

time when he was the Professor of Physics in Allahabad University sometime during the thirties.

Once when Saha recommended some books for the Library, the Registrar, a rule-loving bureaucrat, summoned Saha and asked him, “Have you read all the books in the Library?” When Saha replied in the negative, the Registrar retorted, “Then what do you mean by recommending more books?”

On another occasion, Saha ordered several units of an apparatus called the post-office box. For those of you who do not know, it is basically a device for measuring electrical resistance. Historically, the gadget was invented for use by the British Post Office to detect breaks in cable lines and that is how it got its name. To get on with the story, when the Registrar saw Saha’s indent he was livid with rage and exploded, “There are enough post boxes in the campus; why does this crazy scientist want so many for one single, tiny department?”

Viewed across decades, such anecdotes no doubt appear rather amusing. However, the fact is that as days pass, paper work [some of which is, alas, unavoidable] and bureaucratic delays are not merely increasing but along with it also is the harassment by so-called finance officers who have no stake in anything except in raising endless objections. I can speak on this subject for days, but obviously I shall refrain doing so. I merely wish to say

a) that Bhabha saw the danger clearly and raised his powerful voice,

b) that since then, most top scientists have not bothered about this serious problem as much as they should have, and

c) that if we let the virus thrive and grow, then all the plans we make would be meaningless, since in the end the strangulating effect of bureaucracy would heavily dilute the effect of what we are trying to do.

I would now like to spend the remaining time dealing largely with a topic, where Homi Bhabha’s track record is not exactly shining and glowing, and that relates to university education. When Bhabha got the chance to launch ambitious scientific and technological programs with many dimensions and overtones, he clearly needed plenty of talented scientists in a hurry. Many seized the opportunity and left university positions to join Bhabha, which no doubt pleased him a lot. At the same

time, Bhabha did little to nurse our universities as the main feeder for his various mega programs. Instead, he started a Training School which, in its day, did a pretty good job, meeting fully Bhabha's needs. However, many in the educational sector were utterly revolted by Bhabha's action and strongly criticised him, Raman being one of them.

All that is old hat, but the following historical legacy remains and that is what I wish to call your attention to. To start with I should mention that World War II marked a turning point in that scientific research all over the world began to revolve to a considerable extent around expensive machines like big accelerators, synchrotron radiation facilities and the like, and mega facilities like powerful research reactors. Without exception, all these were no doubt funded entirely by the government, and in the very early days, these facilities were also operated by laboratories established as a part of the atomic energy program of the country concerned.

There were perfectly valid historical reasons for all this, and I shall not go into that here. What happened subsequently is extremely important, but somehow, those radical trends do not appear to have been taken serious note of in India. As I just told you, till about the mid sixties or so at the most, accelerators, reactors and the like were located in labs established, funded and operated by the atomic energy department of the country concerned, whether it was the US, or UK or Soviet Union or France or whatever. Thereafter, thanks to a well-thought out transition program, the primary responsibility for building, commissioning and operating big facilities for Basic Research was transferred to the basic research and the educational sector with, of course, the funds coming directly from the government concerned. In practical terms, this allowed scientists with similar interests in universities big and small to join up, build big machines, and do big science around these mega facilities.

This became the rule in America, Canada and Europe and proved very successful. India followed the world at $t = 0$, that is in placing major facilities under the control of the DAE, but did not cross over at a suitable point like the other countries did. Our situation was of course heavily complicated by the massive control that the government and various political interests exert on the universities and indeed the entire educational system, as a part of the vote-bank politics. Nevertheless, the question arises:

This is the 21st century. Can we let all that 20th century stupidity carry over? Can we let the past arguments, whatever they be,

prevail at a time when the entire ball game has changed, a fact that even countries like Russia, China, Japan and S. Korea have recognised in ample measure? Can our academics just sit around engaging in meaningless finger pointing or, should they roll up their sleeves and get down to some real work, forcing the authorities to come to terms with reality?

My answer to the Young Scientists assembled here would be: **NO! YOU MUST TAKE CHARGE, AND CALL THE SHOTS FROM NOW ON.**

Let me tell you clearly and most frankly that you no longer have the luxury of ivory tower existence that many scientists think they are entitled to. Right now, you personally may be quite insulated from larges woes, but that is because someone else somewhere is taking the heat on your behalf.

Clearly, the present idiotic and meaningless nonsense **cannot** be allowed to continue, and you **have** to pitch in, as a matter of principle. Unless you do so, much of our turf would be eaten away. The result of that would be that everyone would lose, with the country as a whole being pushed backward. And when we get pushed backward, the public, which thus far has not really understood the importance of true fundamental and basic research, would become even more sceptical. I am sure that having come thus far, none of you would welcome such a minor status.

Turning to other aspects of education, there are plenty of things I could say but shall not. I shall instead merely mention the following:

It must all start with at least fifty or so among the top universities representing something like a critical mass, taking the following steps:

1. Quickly get students acclimatised to problem solving, at least where Science is concerned. This aspect has been ignored far too long.
2. Switch to a strong graduate training program in the style that universities in America have done so successfully for well over half a century.
3. Move over from the annual to the semester system.
4. Abandon forthwith the highly rigid “caste” system presently in force whereby a student with a degree in Chemistry must do Ph. D only in Chemistry, etc. Instead, students must have the flexibility to cross register, as is common in the US.

5. Make a deliberate effort to introduce inter-disciplinary subjects.
6. Ensure that Universities with a track record really have the autonomy to experiment with subjects they consider important and relevant, rather than permit bodies like AICTE to dictate terms just because subjects like computer science are involved. Let us not forget that John Bardeen who got the Nobel not only for his work on the transistor but also for his work on the theory of superconductivity, was a professor both in the Department of Physics as well as Electrical Engineering.
7. Lastly, and this is really important, our archaic laboratory training must be thoroughly overhauled. Indeed, this change must occur across the board, starting at the undergraduate level, and embracing as many colleges as possible. To allow the present situation to prolong and continue would be a crime against Science, which, at the practical level, means against ourselves.

On the last point, I would like make a few additional remarks, starting with some personal recalls. When I was in the B.Sc Hons. class in the Madras Christian College, starting in 1951, we had lab sessions many times a week, when each of us was assigned some experiment or the other. There were books written by Cambridge stalwarts that we were supposed to consult, and I honestly tried to read them carefully and prepare myself for every class. But try as I might, most of the experiments simply did not work. I could not believe I was all that dumb and talked to my classmates; and to my surprise I found that they too had similar problems and difficulties.

I am mentioning all this because it was only much later I discovered where the true problem lay. There was no good Teaching Assistant to guide us on how to prepare for an experiment, how to check out the apparatus before getting started, etc. Batch after batch was left to the mercy of a lab attender named Manickkam, a good man no doubt, but unfortunately Physics was not exactly his strong point.

In fact, it was only after I joined TIFR in 1955, that I was rudely pushed into the real world. Over here, I was assigned to work with Dr. Ramanna, and one fine day, Dr. Ramanna casually told me that he wanted me to build a gridded ion chamber for studying the mass spectrum of fission products. Further, he wanted it soon because the Apsara reactor was expected to become operational in a few months. I was shocked and I told myself, "Come on Dr. Ramanna, if you want to fire me why don't you say so directly instead of first torturing me like this? You too are a Christian College product, though many years senior

to me, and you know how well our college trains us don't you?" But strangely, Dr. Ramanna seemed to place a lot of trust in me; maybe, he had forgotten everything about the college we were both from.

Altogether, it was a hair raising experience, especially the part where I had to wind a 20 metre long wire held in constant tension, around a set of closely machined slots on a brass plate that was to serve as the grid. You wouldn't believe it, this was done by Mr. Rama Rao our technical assistant and myself, with me coming down the half-built staircase of the new building all the way from the fourth floor! At that time, the steps consisted of just a skeleton of concrete slabs, with no protective railing. And to wind the wire around the slots, I had to come down slowly, **along the edge**, mind you, along the edge, carefully guiding the dangling wire around the various slots, even as wire hung straight, carrying a heavy spanner down below with Mr. Rama Rao constantly tugging the spanner.

If the wire was under tension, so was I! It took me 30 minutes to complete the job, and I still do not know how I fought vertigo and avoided crashing down from the fourth floor.

The reason I brought this up is merely to say our college training does not even teach us the basic principles. How then can one expect the graduates to step into research without messing up things for quite a while?

Can we really afford that kind of waste in these times? In my case as in that of almost all of us who were here at that time, we learnt our tricks and the basics from a set of books called the Manhattan Bible – there were at least a dozen books belonging to that set, and they collectively represented the experience gained during the famous Manhattan Project in Los Alamos that culminated in the design and fabrication of the first atom bombs. The Manhattan Bible covered a whole spectrum from nuclear physics to radiation biology and instrumentation. They were extremely informative and educative and I really got my first introduction to hard core experimental physics, design of experiments, how to design equipment and get it fabricated, tested etc., all from that invaluable set of volumes.

By way of completing the story of the ion chamber that I built, I am happy to say that when Apsara finally became operational, the chamber was actually used by Dr. Ramanna and his group including Dr. Kapoor, to obtain interesting results and a paper also was duly published. Only, I

found that my name was at the wrong end of the paper, shall I say! However, Dr. Ramanna was very nice and sent me to Belgrade to attend a IAEA conference on Nuclear Electronics, which was also attended by Prof Srikantan, later to become Director, TIFR. Over in Belgrade, both of us along with Mr. Vaze of BARC and some Pakistanis who also were attending the same conference, had a jolly time. By the way, in those days, Belgrade was the capital of Yugoslavia, a country that no longer exists!

Thus far, I was speaking about how ill prepared I and all others like me were, for the real research world, thanks to a lack of good hands-on experience in the college. I would now like to call attention to a similar and a very important deficiency that afflicts our research community as a whole, but has received almost no attention at all thus far.

The best way of placing the matter in perspective is to call attention to what has happened and is continuing to happen on an increasing scale in the advanced countries concerning large research facilities such as intense neutron, muon and synchrotron sources, all of which are indispensable for condensed matter research and huge accelerators that are vital for high energy research, apart from exotic telescopes, satellites etc., needed for astrophysical research. Take a look at what is happening in China, where they have an electron-positron collider at Beijing. OK, it is not the world's number one, but is keeping China in the race. What is interesting is that since one of the Charm factories in America has shut down, many Americans are now headed for Beijing. And this is how Prof. Ron Poling of the University of Minnesota puts it: "Thanks to the Chinese, we may be able to answer some of the most compelling questions in particle physics."

Most of us are so focussed in improving individual CV's that the national perspective is constantly pushed to the back burner. I am afraid, this cannot go on for too long. If we persist, we would be never be counted among the big boys. At a time when we are trying to recall Homi Bhabha's great achievements, please take a minute to ponder about what I have just said.

Can I throw you young scientists a challenge? Stanford has just commissioned the LCLS or the Linac based Coherent Light Source, which is really a giant laser that goes one step beyond what synchrotron radiation allows one to do. This machine is expected to peak in about two years. Here's what I suggest:

Why don't we resolve that this country shall have a LCLS by say 2016? A tough job I agree, but then India has reached a stage where it **can** do it provided, **you** the potential user, are willing to throw your weight behind it. Even if the machine we build in 2016 is only 50 % as good as what Stanford has, it would still be a damn good machine. Take it from me, even with the awesome Spallation Neutron Source that has just become operational in America, with optimal use and imaginative squeezing, we can still get a lot mileage out of DHRUVA reactor with its 10^{14} flux. The problem is that neutron sources in India are tied up with the DAE, which means inevitable and unavoidable security barriers. The LCLS can be entirely outside of DAE and be built entirely by the pure research community. However, that calls for a lot of teamwork, working at the drawing board and stuff, which are simply not acceptable to people chasing papers all the time. And let me tell you, I know a thing or two about doing science around big facilities. Just as our college experience does not prepare us for real research, likewise, push-button research without innovative instrument building which has almost disappeared in this country, is not helping us where the creation of big facilities are concerned. If we do not step into that league, on our own credentials as competent research scientists, rather than via the coat tails of the DAE, then take it from me that we are writing our own ticket to oblivion.

I hope I have said enough to provoke you to do some out-of-the-box thinking. Some of you might feel all that is beyond you arguing, "Look I am not made like Bhabha." Actually, we do not have to be Bhabhas. All we have to do is to grit our teeth, roll up our sleeves and get to work. In this context, it is worth recalling what Raman said to young graduates many, many years ago, before Independence in fact. This is what He said:

I would like to tell the young men and women before me not to lose hope and courage. Success can only come to you by courageous devotion to the task ahead of you, and there is nothing worth in this world that can come without the sweat of our brow. I can assert without fear of contradiction that the quality of the Indian mind is equal to the quality of any Teutonic, Nordic or Anglo-Saxon mind.

What we lack is perhaps courage, what we lack is perhaps the driving force which takes one anywhere. We have, I think, developed an inferiority complex. I think what is needed in India today is the destruction of that defeatist spirit. We need a spirit of victory, a spirit that would carry us to our rightful place under the

sun, a spirit which will recognise that we, as inheritors of a proud civilisation, are entitled to a rightful place on this planet. If that indomitable spirit were to arise, nothing can hold us from achieving our rightful Destiny.

Those electrifying words were spoken about seventy years ago. Unfortunately, much of what Raman said is still true. However, there is no reason to feel diffident. I do hope you find Raman's passionately delivered and emotionally charged words inspirational; I always do.

Finally, since we are gathered here to honour Bhabha, maybe I should end with a small Bhabha Story!

STORY

Thank you Prof Barma, thank you audience, and to TIFR I say, using the words of a song made famous by Bob Hope: THANKS FOR THE MEMORY.

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