

ANNEXURE

Dr. Homi Bhabha and the early years

By Prof. B.V. Sreekantan, former Director TIFR

Dr. Bhabha had a very unique educational career in the sense that he first completed his tripos in mechanical engineering from the Caius College at Cambridge in 1930 and then joined as a research student in theoretical physics. His work on several aspects of particles and their interactions during 1930's, particularly the development of Bhabha-Heitler cascade theory, earned him permanent recognition as a great mathematical physicist with abundant intuition and imagination. These two different aspects of his education later helped him in pursuing activities of diverse nature at IISc, TIFR and DAE.

In India, he established the Cosmic Ray Research Unit at the Indian Institute of Science, Bangalore as part of the Department of Physics headed then by Sir C.V. Raman, to initiate a very active experimental program. Being aware of the special advantage that India had for cosmic ray work because of the wide range of latitudes available from the magnetic equator in the south to 25° N magnetic latitude in Kashmir and the possibility of observations at a wide range of high mountains, he embarked on a programme of experimental studies of the cosmic ray penetrating component. While he held active discussions with the mathematicians of the Central College in his theoretical studies, he also interacted with the members of the communication engineering department of the institute for his experimental studies. He designed a unique Geiger counter telescope that preferentially selected the penetrating component without requiring too much lead absorber and flew the telescope in an airplane to an altitude of 32,000 feet. This constituted one of the first measurements of the latitude effect of mu-mesons at high altitude. He got a 12" diameter cloud chamber constructed for a systematic study of the scattering of mesons. Therefore, it was natural that mathematics and theoretical physics and experimental work in cosmic rays and high energy physics were among the first research areas to be later taken up at TIFR. He gave the utmost importance to experimental research in frontier areas and was fascinated by the

observations on the relationship between matter and energy as revealed by experiments using nuclear emulsions and cloud chambers, for example, gamma quanta transforming into electron-positron pairs, high energy electrons radiating gamma quanta and energy radiated as particles in high energy interactions. His fascination with these experiments and the particle-field relationship underlying these processes led him to agree to establish a laboratory for cosmic ray research at Ooty in December 1954 when the then Governor of Madras, Shri Prakasa, offered him suitable place within the campus of the Raj Bhavan. His interest in understanding the fundamental processes underlying the interplay between energy and matter as seen at various wavelengths in the Universe was so strong that he happily climbed various hills in the Nilgiris when selecting a suitable site for the Ooty radio telescope. Similarly he strongly encouraged our group to explore the muon and its properties by carrying out experiments deep underground inside the mines at Kolar Gold Fields. He was very pleased with the fact that the first observation of the interaction of an atmospheric neutrino was made in KGF mines by an international collaboration led by the scientists from TIFR.

(i) Social Vision of Dr. Bhabha: The social vision of Dr. Bhabha was something that was very unique. Talking about this aspect at Bhuvaneshwar on the 3rd of January 1977, Professor R.E. Marshak of U.S.A. said " ... I first visited your country in 1953 as a guest of your illustrious scientist Homi Bhabha, who invited me to lecture at the Tata Institute in Bombay. I was greatly impressed at that time - when most creative scientists in the United States declined to shoulder any social responsibilities - by the social Vision of Dr. Bhabha, by his dedication to humanistic values and by his intense commitment to the welfare of India and its people. Having experienced the joys of profound creative research in Theoretical Physics Dr. Bhabha was nevertheless ready and willing to surrender that happy life so that he could contribute his broad talents to help establish a comprehensive scientific

infrastructure in India and ensure that the fruits of scientific advance and technological development would serve his fellow citizens”.

(ii) Administration of scientific institution: Dr. Bhabha was convinced that the mode of administration of a scientific institution had to be different from the type of administration in the government or in an industrial house. He introduced several new features in the administrative pattern of TIFR which proved so successful that they were later adopted in other scientific institutions in the country. He created two scientific bodies - the Physics Faculty and the Mathematics Faculty – and these were given full responsibility for scientific programmes, conferences, symposia, evaluation of scientists and their promotion etc. The Deans and the faculty members in charge of the various disciplines had been delegated sufficient financial and other powers that the work of the Institute was not interrupted.

(iii) Early Recruitment and Training of Personnel: As I walked into Dr. Bhabha’s room for the third time in the course of an afternoon on the 6th of August 1948, he said with his characteristic smile “We have decided to admit you as a research student. Tell us whether you would like to do theoretical work or start work in an experimental area”. I had been interviewed twice that afternoon - the first time by Dr. Bhabha and a few experimentalists and the second time by Dr. Bhabha, Professor D.D. Kosambi and Professor F.W. Levy, a mathematician. Like all young men in similar circumstances and anxious not to let go the opportunity of joining TIFR, I replied “Sir, I leave it to you. You have interviewed me and you are the best judge”. Thereupon, Dr. Bhabha said, “Look here, if you start doing experimental work, there is a possibility that if you are really interested, you may be able to do theoretical work also but the other way is almost impossible. Moreover, you have some background in electronics; if I were you, I would work in an experimental area. Of course the final choice is yours.” Well I took his advice and joined the Cloud Chamber Group of TIFR on the 16th of August 1948 and I have had no cause to regret. The personal involvement of Dr. Bhabha in the selection of

research students and research associates continued for several more years until he became extremely busy with the atomic energy programme of the country. In parallel with the recruitment of fresh graduates from the universities, Dr. Bhabha also started inducting postdoctoral scientists into the Institute at various levels. For this purpose, he very effectively used the international travels he undertook frequently to participate in scientific conferences and in connection with the work of atomic energy programme. While on the one hand a steady flow into the Institute of Indian scientists who had worked in various laboratories abroad continued, Dr. Bhabha also ensured that the young scientists who had joined TIFR immediately after their university education, got opportunities to go abroad and gain experience in some of the very important centres of research and development.

I must also emphasize the fact that Dr. Bhabha had great confidence in the abilities of young Indian scientists. To achieve the desired objectives suitable working environment was created to unleash their creativity. His encouragement and support for the establishment of the Training School of the then Atomic Energy Establishment for attracting and motivating young graduates in science and engineering was well known. In fact, the Training School provided the bulk of the scientists and engineers during 1950’s and 60’s for the research and development programmes of various institutions supported by the Department of Atomic Energy, including the TIFR. His confidence in the abilities of these young researchers was amply justified by the successes achieved by various programs.

(iv) Philosophy followed in the growth of TIFR: In a speech Dr. Bhabha delivered at Bombay on the 7th January, 1966 “On Science and the Problem of Development” at the invitation of the International Council of Scientific Unions, he spelled out the philosophy he had followed in the growth and development of TIFR. He said “No organisational chart of the future development of the institute was submitted either when it was founded or later and the philosophy has always been to support ability whenever it is found in the fields of work covered by the Institute. Indeed the philosophy underlying

the founding of the Institute was the same as that underlying the Max Planck Institutes in Germany, namely 'The Kaiser Wilhelm Society shall not build an institute for research and then seek out the suitable man, but shall first pick an outstanding man and build an institute around him'..." He also mentioned in his ICSU talk how he started the activities in the areas of Molecular Biology and Radio Astronomy in TIFR only when he was able to identify the scientists who had the necessary caliber to lead these activities in the institute.

(v) The Wednesday Colloquium: One of the important weekly features that was started by Dr. Bhabha almost from the time of inception of the Institute and which continues even now is the "Wednesday colloquium" at which a talk on a topic of general interest is given by one of the members of the Institute or by a visiting scientist. Unless Dr. Bhabha was out of station, he always made it a point to attend the colloquium and actively participated in the discussions. He also used the Wednesday colloquium to form a general impression on

the depth of understanding and the extent of direct involvement of the scientist who gave the talk apart from judging other qualities like mode of presentation, ability to talk fluently, etc. In the very early days, Dr. Bhabha himself used to give talks at the Wednesday colloquia. It was indeed an intellectual treat to hear him. At the end of the talk we would find all the salient points written down neatly on the blackboard in a systematic manner. He had a flair for presenting complicated theoretical ideas in a very simple easily understandable way. In the later years, when Dr. Bhabha became more busy with the atomic energy work, Wednesday became for him the TIFR day in the week. The meeting of the Physics Faculty of the Institute was invariably fixed for a Wednesday morning followed by colloquium. "No decision was ever taken without a full discussion."

*As narrated to Prof. S.C. Tonwar
of TIFR*

By Prof B.M. Udgaonkar

I joined TIFR in 1949. At that time TIFR was a small place with only a few members. There were, in addition, some others who were attached to the newly established Atomic Energy Department, but we all worked together. There were hardly any senior members, the so-called faculty. In the previous years, only one or two students were taken in at a time. In 1949, many students joined TIFR. But there was practically nobody between the students and Bhabha, the Director. This was also true for the selection of the students. I was interviewed by Dr. Bhabha himself. Another committee member asked me a question the answer to which I could not have known at that time. Dr. Bhabha immediately intervened and remarked that I should be asked something else that I might have studied. I was then thoroughly interviewed on topics that I had studied and, of course, I did well. This incident influenced my own approach to interviewing prospective candidates in TIFR later. The philosophy adopted was to find out what a person knew and how well he knew it rather than how much he did not know. My interview was held at old Kenilworth building at Peddar Road, a small mansion belonging to Bhabha's family. Two months after I joined, the institute had shifted to the Old Yacht Club, which now houses the office of Chairman Atomic Energy Commission and Secretary, Department of Atomic Energy. Here on the first floor there was one big hall that was converted into a library and the few of us who had joined the theory group were assigned some tables in the library. There were labs on the ground floor. In addition, there were two buildings adjacent to the Old Yacht Club - servant quarters, I think. The ground floor was used as a laboratory, and the rest as a hostel.

Bhabha's philosophy was of first finding a suitable person and then built the activity around him. For example, the leaders of various groups were picked up and activities grew around them. Ramanna joined around this time and P.K. Iyenger joined as a student a few years later. Various activities grew around Phadke, Rao, Dharmatti. Thus, the thrust areas evolved gradually. For example, work on cosmic rays started pretty early. Dr. Bhabha himself was engaged in some work on cosmic rays; A.S. Rao was involved in building some

instruments for cosmic ray experiments. Dharmatti along with his students took up the job of building equipment for NMR studies. Phadke built up technical physics activities and was involved in electronics and the linear accelerator programme. In course of time, some of these activities developed into the large technical physics activities of BARC, and had major spin-offs like SAMEER and the Electronic Corporation of India. A year or two later, interest developed in building reactor physics activity. Mathematics was being pursued right from the beginning. Since there were not many senior scientists to help the students and hence in the areas in which there had been no specific expertise available several distinguished scientists from abroad were invited for 2-3 months period for extensive lecture programmes. Among them I remember Wentzel who came more than once; Rosenfeld, the nuclear physicist; Pauli gave a course on quantum electrodynamics; then Seber, Gamow and so on. Dirac also came and gave a course on quantum mechanics. Salvetti also visited and gave a course on reactor physics. Dr. Bhabha also used to meet the students periodically. One of his valuable advice was to maintain a log book on the problem we were working on.

In the early, days there were no graduate courses and people just went into research directly. Whatever was needed had to be studied on one's own. For example, in my first meeting with Bhabha, he asked me to study Dirac's book on quantum mechanics and the book on mathematical methods by Courant & Hilbert and see him from time to time. I worked on two problems with Dr. Bhabha. In the early fifties he had written some interesting papers on his model of elementary particles. Of course, as you know, the fashions in particle physics change every few years and this work went into the background. But he had proposed an interesting equation which could describe a particle with two different states of spin and mass, a spin half state and a spin 3/2 state, and could therefore possibly describe the nucleon and the delta resonance. It looked like an attractive proposition. So he asked me to quantise the equation, which I did.

By the late 1950s, several bright students had joined the theory group, some of them before the atomic energy training school was started and some afterwards e.g. Virendra Singh, R.K. Verma, Warke, Jha, Divarkaran, Mukunda,

Rajasekharan. At that time there were no graduate courses at TIFR, there were very few people to guide research scholars in theory, so a conscious decision was taken to send these young students, after a couple of years at TIFR, to different schools abroad for their Ph.D. Virendra Singh went to Berkeley, Jha to Stanford, Warke to La Jolla, Divakaran and Rajasekharan to Oxford and then to Chicago under Dalitz, Sudarshan and Mukunda to Rochester, and so on. This worked well. All these people came back (except Sudarshan), grew in stature and became leading figures in Indian science and this reflects Bhabha's instinct for selecting the right people. Here, I do like to mention an important incident. Around 1960 Abdus Salam was visiting Bombay and we were still struggling to establish an activity in theoretical physics. Pandit and I were talking to him – Salam was still based in London and had not yet moved to Trieste, Italy - and I invited him to spend his summer vacation here. He said he would rather go to U.S. Then he added something that hurt us; he said he did not think that any good physics could be done in this part of the world. Of course, we proved him wrong in a few years.

Bhabha had the vision to build a very large workshop at TIFR to serve not only the institute but also the atomic energy establishment. The infra structure available in the private sector then was inadequate. Research students were asked to build various items of equipments they needed, a power supply, multi channel analyser, a counter, or whatever. They went through it the hard way, instead of buying

equipment off the shelf and that came in very handy afterwards. This culture of self-reliance was crucial for the Department of Atomic Energy. When the need came, whether for the nuclear power or Space programmes, the expertise was already there in the different departments of the establishment. The vision of atomic energy programme that he had laid out has remained essentially unchanged. His whole vision seems to have been that atomic energy be developed for peaceful purposes but if the need arose one should be ready to face technology denial regimes, or the option for making weapons.

Bhabha was, no doubt, a great scientist, a great administrator and a great patriot. He had an artistic taste and temperament. He was aristocratic in his attitude and this I feel was an added dimension to his personality that must have helped him to build big things and have a big vision. There is a book written by a Canadian social scientist named Anderson, on Bhabha and Saha, wherein he has tried to relate Bhabha's family background and personality to the way he built up institutions. I had talked at length to Anderson when he visited TIFR. His analysis then appeared to me to be simplistic, but I now believe there may be some truth in it.

In concluding I may say that the seeds of excellence that one witness now at TIFR or BARC were sown by Bhabha right in the early years of their establishment.

*As narrated to Prof. Arvind Kumar
of HBCSE, TIFR*

By Dr. Raja Ramanna, former Chairman AEC

We were lucky that Dr. Bhabha had excellent sense of organization, which benefited the DAE, be it human resource development, basic research or the power sector. He had formulated the atomic energy program with a wider vision and brought it to a stage that it did not degenerate after his sudden demise, rather the Department continued to move upward.

The scientific programs of DAE were charted keeping the country's long term needs in view. Notably, they got the full support of Pandit Nehru and this fact is often considered to be the major reason for the success story of DAE programmes in the years to come. Realizing that India has rather limited deposit of uranium and abundance of thorium, he drew up a three stage long term nuclear power programme. This required to initiate comprehensive R&D programmes and build facilities for the entire fuel cycle. Today, IGCAR has become very central to the long term nuclear power programme. While, pursuing a comprehensive nuclear power programme, Bhabha was convinced that pure and long term research is a must for the success of the programme and accordingly he planned different research programmes which eventually attained maturity and helped to carry on various programmes when the international sanctions were imposed after Pokharan-I experiment.

The work culture promoted within DAE has been quite unique on many accounts. One of the remarkable feature is

that the commitment to work has always been held higher than the individual glory / gains. The whole execution of Pokharan-I experiment is an example of the excellent work culture promoted amongst the staff members.

Dr. Bhabha was convinced that the development of right manpower is crucial to our programme. Considering that specialized training was required to initiate the newer programmes and the fact that these topics did not form part of the regular courses in most of the Indian universities at that time, it was decided to start the Training School in the year 1957. Indeed, it was a brilliant idea of Bhabha and we all know that it has played a major role in the development of nuclear science and technology in the country. He was able to inspire large number of brilliant young scientists and engineers not only in the field of nuclear technology but also in many others.

Bhabha had a unique sense of carrying out the scientific administration and was thus successful in evolving a strong bond between the scientific and the administrative staff and to achieve this he used to periodically lecture his administrative staff. Bhabha had some very good people and knew how to effectively utilize their talents.

As narrated to Prof. G. Rajasekharar of IMSC.

Biodiversity

BARC campus is home to many plant species. The flora in and around BARC campus is undisturbed since the inception of Bhabha Atomic Research Centre in 1954. Though several ornamentals were introduced in the last 50 years the unique flora of natural vegetation is very well preserved. Nearly 534 species of plants belonging to 338 genera under 86 families of flowering plants were documented in BARC campus. A new plant viz *Firmiana colorata* var. *subglabra* was discovered on this campus. In addition to these, 892 species belonging to 97 families of cultivated plants are found in BARC campus. These plants are either of Indian origin or exotic. Special mention can be made of *Adansonia digitata* a tropical African tree with massive trunk and *Ravenala madagascariensis*, a traveller's palm from Madagascar, *Camelia japonica* a wild tea plant and *Muntingia calabura*, a plant from South America. Among the fauna, 86 species of birds belonging to 28 families, several species of reptiles, mammals and insects have also been detected in Trombay.



***Firmiana colorata* (Roxb var. *subglabra*; Abraham and Dutt):** A new plant discovered in Trombay and added to plant taxonomy. Scarlet red flowers of *Firmiana colorata* are seen in the above picture



***Sterculia diversifolia* (Pagal patta):** A plant which has leaves in variety of shapes and sizes, nurtured in BARC campus



***Hyphaene indica* Becc** : A rare dichotomously branching palm growing on rocky hill slopes of Trombay



Corypha elata : A palm which flowers only once in forty years (BARC)



***Adansonia digitata* (Baobab tree – Gorakh imli)**: Longest lived tree species found in Trombay



***Ficus krisnae* Krishna-Vat**: Typical cups of leaves (BARC)