

# **Fifty Years of TIFR Graduate School**

**A Commemoration**



## Message from the Director

It is a pleasure to present to you this commemorative issue on the Golden Jubilee of the Graduate School of Tata Institute of Fundamental Research (TIFR), an Autonomous Institution of the Department of Atomic Energy (DAE), Government of India. For the last seven decades, TIFR is at the forefront of research in basic sciences in India. Beyond this, it has been playing a role in nation building in two important ways: by creating new institutions, and by training top class young researchers who now have a significant presence in most major academic institutions in the country. The Graduate School of TIFR, formally established in 1969, has contributed in a crucial way to these various dimensions of the Institute. While lecture courses for research scholars by senior researchers and eminent visitors had started right from the inception of TIFR, formalized coursework in the School of Physics started about 50 years ago, which later culminated in the recognition of TIFR as a Deemed-to-be University in 2002.

TIFR, at its main campus in Colaba and in its research centres in Bengaluru (Centre for Applicable Mathematics, International Centre for Theoretical Sciences, National Centre for Biological Sciences), Hyderabad (TIFR Centre for Interdisciplinary Sciences), Mumbai (Homi Bhabha Centre for Science Education), and Pune (National Centre for Radio Astrophysics), offers M.Sc., Ph.D., and Integrated M.Sc.-Ph.D. programmes in Mathematics, Physics, Chemistry, Biology, Computer & Systems Sciences, and Science Education. The research carried out in all branches of TIFR has had significant contributions from the students who received their education as well as exposure to cutting-edge research in the Graduate School.

As the Graduate School completes its 50 years, in the same year as the TIFR enters its 75<sup>th</sup> year, it is time to reflect on the role of graduate schools in the current global landscape of education, and be ready for further challenges. I thank the TIFR Alumni Association for taking the lead in organizing the GS-50 event to discuss the past, present, and future of the TIFR Graduate School.

**S.P. Trivedi**  
*Director, TIFR*

## Foreword from the Convener, GS-50

Fifty years of any program is a reasonably long time to evaluate its impact. The Golden Jubilee of the formal graduate school of Physics in TIFR (which encompassed Physics, Chemistry, Molecular Biology and Computer Sciences) provides us with such an opportunity. The School of Mathematics has been running their graduate programme even longer.

Several of the TIFR alumni have distinguished themselves in the field of academics, industry and science administration. We felt that in addition to organizing an event to celebrate this occasion, these alumni as well as some eminent academicians from other institutions should be invited to discuss the impact of graduate schools in India and how to increase their effectiveness further. Arun Grover provided the initial trigger for this idea, and the TIFR Director gave his immediate and enthusiastic support. Indeed, the year 2020 would be the 75<sup>th</sup> year of TIFR, and the “GS-50” event on Nov. 1-2, 2019 would mark the start of the Platinum Jubilee commemoration. The event has been made possible by generous support by Tata Trusts and the TIFR alumni.

It was decided to bring out a special “GS-50” commemorative issue on this occasion, containing the history of development and evolution of various branches of the TIFR Graduate School, along with reminiscences from alumni. Amol Dighe and Vandana Nanal have taken the major responsibility of editing it, but the responsibility of any omissions or errors lies with the entire Organising Committee. Sukant Saran deserves special thanks for designing this document. We hope that this issue will be a valuable addition to the records of TIFR history.

I would like to thank the entire Organising Committee of GS-50, which has worked as a team for the past few months. It has been a pleasure to work for this event.

**Amit Roy**  
*Convener, GS-50*

## TIFR Graduate School: Yesterday, Today and Tomorrow

It has been 50 years since the Faculty of Physics (consisting of physics, chemistry, molecular biology, and computer science) started the TIFR Graduate School (GS). Formal coursework for Ph.D. students was not common those days, though it has become a requirement for all Ph.D. degrees in the country today. The TIFR GS has evolved in the setting of TIFR the Research Institution, and hence has always been built around the expertise of the faculty members, responding to their changing interests and needs. Keeping to the ethos of TIFR, the evolutions of various GS programmes have been quite organic, led by the subject experts from within. As a result, the programmes in different subjects have developed quite independently, though there is a common thread of consensus that Ph.D. students coming out of TIFR must have a solid foundation of knowledge in their subject areas.

TIFR GS has come a long way in the last fifty years. Until 2002, all the students in the graduate school were awarded degrees by the University of Mumbai (then University of Bombay). TIFR became a Deemed-to-be University in 2002, and started awarding its own degrees in the six disciplines of Physics, Chemistry, Biology, Mathematics, Computer and Systems Sciences, and Science Education. While most of the students enter the graduate school for Ph.D., there are also M.Sc. programmes in Biology as well as Wildlife and Conservation. Over the last decade, the Integrated M.Sc.-Ph.D. programmes in most subjects have started admitting more students directly after their bachelor's degrees, to enable some of the brightest Indian students to get an early start in high quality research. The TIFR Deemed-to-be University confers about 100 degrees per year. It has been accredited in 2016 by NAAC with a grade of A+ (3.68/4). It is one of the few universities in India which offers a Ph.D. degree in Science Education.

Over the years, many students coming out of the Graduate School have established themselves in the scientific community, some already holding prestigious faculty positions in India and abroad. Many of them have played important roles in teaching, research, and administration, both at the national and international levels. Their scientific contributions have been acknowledged with Padma awards, Shanti Swarup Bhatnagar and Infosys awards, Swarnajayanti fellowships, ICTP, TWAS and New Horizon prizes, as well as Fellowships of Science

Academies in India and abroad. They have been leaders in mega-science projects like KGF, GMRT, SC-LINAC, Astrosat, INO, CMS, LIGO-India, FAIR, TMT, SKA, etc. The contribution of Graduate School in their scientific development has been acknowledged by many in the “Reminiscences” section later in this document.

The major advantage of a Graduate School in a Research Institute setting is that the students are exposed to research right from the first day. The flexibility offered by the structure also allows the instructors to introduce discussions of emerging areas and the topics of their own expertise in the coursework, which keeps the courses relevant and interesting. The admission in the TIFR GS is very competitive (more than 25000 students appear every year in the written entrance test in all subjects), the coursework is very challenging, and the Ph.D. research is at the cutting edge. The coursework has become more structured over the years, still retaining its flexibility. The processes have become standardized, still retaining their agility and the policy of keeping the welfare of the students first.

While TIFR does not award undergraduate degrees, the GS does cater indirectly to the undergraduate community in India. A large number of undergraduate students in the country participate in the Visiting Students’ Research Programme (VSRP) in summer every year, and many do their Bachelor’s and Masters’ projects in TIFR labs. The National Initiative for Undergraduate Science (NIUS), run by the Homi Bhabha Centre for Science Education (HBCSE), allows students pursuing an undergraduate science degree to work with a TIFR research advisor for up to three years. HBCSE is also the nodal institute for the national Olympiad programmes in mathematics and sciences for high school students. Many TIFR faculty members have organized, and participated in, various Teachers’ Training Programmes for college and university teachers.

In the changing landscape of higher education in India and the world, the role of the Graduate School also cannot remain static. How can TIFR expand its reach, and be accessible to a much larger student population in the country? How can it retain its uniqueness – its quality and its focus on research – in the light of the National Education Policy? How can it leverage its strengths to the advantage of itself as well as the nation? Can it focus on postgraduate education, and establish itself as a “knowledge resource centre” for other Higher Education Institutions? This needs introspection and planning for the future, taking inputs from peers and stakeholders. The GS-50 event has provided us the opportunity to do so.

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## Development of the Graduate Program





## Genesis of the Graduate School

The genesis of doctoral research programmes at Tata Institute of Fundamental Research (TIFR) is due to the vision of Dr. Homi Bhabha, who recognized the need for the highest quality human resource in different spheres of science to propel the technological development of India. To start implementing his long term plans of achieving self-reliance in harnessing nuclear energy and research in other strategic areas, he initiated the induction of bright students graduating from the best University Departments all across India. Dr. Bhabha provided these young aspirants with 'intelligent financial support' and stimulating conditions of work in the form of training under carefully inducted in-house scientists comprising physicists, mathematicians, chemists and engineers. These young students acquired a solid foundation in their respective areas, which not only enabled them to kickstart the sovereign India's Atomic Energy programme, but also helped them emerge as excellent academicians and intellectual leaders contributing to the nurturing of newer national institutions, like IITs, national laboratories, numerous central and state universities, etc.

Dr. Bhabha had sought the affiliation of TIFR to University of Bombay, from its very inception. The choice of its Colaba campus, in spite of being in the defence area of South Bombay, was largely influenced by its proximity to the University buildings in the Fort area. As the laboratories of TIFR gradually took shape, Dr. Bhabha extended the use of library and experimental facilities of TIFR to the teachers and scientists from other affiliated institutions of the University, and encouraged them to attend advanced lecture courses given by TIFR staff and invited distinguished visitors. The visitors to TIFR included L. Schwarz, C.L. Siegel, W.H. Heitler, Paul Dirac, George Gamow, N. Dallaporta, J. Hartmanis, David Gries and C.A.R. Hoare. Often students were assigned to take notes for these lectures, which were cyclostyled and made available in the book format with yellow cover. In the meanwhile, the Atomic Energy Establishment Trombay (AEET) had been nucleated, and an AEET Training School (TS) was started to induct engineering and science graduates in much larger numbers from 1957 onwards. Dr. Bhabha's first theoretical physics research student at TIFR, Bhalchandra Madhav Udgaonkar (BMU), had played a key role in teaching trainee scientific officers of TS and new Research Assistants of TIFR. In 1958-59, L.K. Pandit taught the basics of Quantum Field Theory, which was perhaps the first regular physics course at TIFR.

To accelerate and expand the process of trained human resource for ambitious large scale experimental programmes of TIFR, Dr. Bhabha facilitated training of a few of select promising young researchers from TIFR and bright Scientific Officers graduating from AEET TS, at distinguished institutes and universities abroad. Concurrently, at the new premises, the earlier Research Assistant / Research Associate scheme was replaced by a new programme of Visiting Members / Senior Visiting Members for Ph.D. students / Post-Doctoral Fellows, respectively.

Dr. Bhabha had enabled his protégé, BMU, to have extended sojourns in Berkeley, Institute of Advanced Study (Princeton) and Argonne National Laboratory. After his return to TIFR, Dr. Bhabha designated him as the Head of Theoretical Physics Group in 1963. In addition to guiding Ph.D. students at TIFR, BMU engaged with promising undergraduate physics students studying in the affiliated colleges of Bombay University. (The Physics Department of Bombay University came into being several years later, as M. C. Joshi was inducted from TIFR as Professor and Head.) He also encouraged other passionate colleagues and Ph.D. students to regularly interact with these young local students.

The sudden passing away of Dr. Bhabha in 1966 did not slow down the progress towards the creation of a structured Graduate School programme in Physics, with advanced pre-Ph.D. course work prior to the registration for the Ph.D, similar to those in the Universities in US and Canada. In his famous last address delivered on January 7, 1966, Dr. Bhabha had stated “the institute has now reached the stage when it is able to feed good scientists into the Universities, an aim which will be followed to an increasing extent in coming years”.

Most of the young persons from TIFR, who had gone abroad for Ph.D., started to return as M.G.K. Menon took over as the Director. The NSTS (National Science Talent Search) Summer School for M.Sc. students, who had been selected for the first time on all India basis as NSTS scholars in 1964, was organised at TIFR in June 1968. After a taste of one month stay as visiting summer students, many NSTS students expressed the desire to enrol for Ph.D. at TIFR. As a result, TIFR expanded the intake of Visiting Members, but it also started to restrict the inductions from AEET (now BARC).

The well-known “Group Committee V”, initially chaired by BMU, was set up to look after the Graduate School (GS). The admissions for the structured GS Programme in Physics at TIFR commenced in August 1969. The construction for the new hostel on the Colaba campus for Ph.D. students had begun in right earnest, but it became available for occupation only by the end of 1971. As the students admitted to GS in Physics started to qualify for Ph.D. registration through the graduate courses, the practice of issuing grade cards was initiated by the newly constituted Graduate Study Committee (GSC), with S.S. Jha as its first Chairperson. The committee continued being known as “Group Committee V” in popular parlance.

B.V. Sreekantan, the first experimental physics research student of Dr. Bhabha, took over as Director, TIFR from M.G.K. Menon in 1975. TIFR had inducted very few young scientists in the regular academic stream after the start of the GS. Sreekantan was concerned that the large scale experimental programmes, which had been the USP of the institute, were not getting enough students through the time-bound Graduate School programme. Given the nature of these programmes, it was necessary for students to put in several years of work

to meaningfully contribute to a given project, and a fixed 5-6 years duration was not enough to produce new scientific results to merit a Ph.D. degree of TIFR norms. He, therefore, proposed in 1976 to induct research students in two streams as Research Scholars and Research Trainees. The latter were to proceed to field stations as they joined, the former were to undergo Graduate School course work as earlier. The Research Trainees were to be absorbed as Research Associates after two years and they were expected to complete course work requirements over an extended period, as and when their assigned duties permitted them. This dual scheme was discontinued from 1979, and thereafter all Ph.D. students were admitted as Research Scholars. From 1979 to 1984, the formal graduate school course work activities were much reduced, and only special courses were given based on requests from the new batch of students, which included evening lectures.

The rigorous Graduate course regimentation was brought back in 1985 in the School of Physics of TIFR. The courses were still conducted somewhat informally, with the syllabus and assessment procedure being largely chosen by the teacher. Concurrently, in partnership with Department of Physics of University of Poona at Pune, a joint M.Sc. programme in Physics for twenty students (specially selected on all India basis) was launched, as the National Centre for Radio Astronomy (NCRA) of TIFR came up contiguous to the University campus. Though this joint M.Sc. programme was discontinued after three years, the TIFR GS for post-M.Sc. students has continued uninterrupted all through.

A proposal was made to the Director to give appropriate weightage to teaching activity of the Academic Staff, which was implemented by V. Singh in 1987. Probir Roy took over as the Chair of GSC in 1990. A progress and evaluation committee was formed for each student and his/her progress was systematically monitored. The elevation of a student’s honorarium was linked to his/her registration with the university. There was enthusiasm among the faculty - especially the young experimentalists - in teaching and guiding projects in the Graduate School. A culture of students giving seminars was established. A student’s seminar before his/her submission of the thesis abstract was made mandatory.

In 1997, the Natural Sciences Faculty (NSF) was formed and the Graduate School became its integral part. At this time, TIFR was growing and its student intake was rapidly increasing. The practical difficulties of working through Bombay University also began to become an impediment. Around 2001, in a high-level Committee chaired by S.S. Jha, it was decided that TIFR should apply to UGC to become a Deemed-to-be University. He reckoned that this status was essential for TIFR in order to enhance the gain from its GS programmes in its different disciplines/schools and Centres. The major advantage of a Deemed-to-be University (DU) in a Research Institute setting is that the students are exposed to research right from the first day. In addition to the selection of M.Sc. qualified students, the students with a Bachelor’s degree in Sciences/ Engineering (with an exit option to obtain M.Sc. degree

after three years) could also be accepted for the Ph.D. programs of a DU. The approval of DU status of TIFR came around 2002, when Prof. S.S. Jha was the Director. The DU is headed by an Academic Council, chaired by the Director, modelled similar to the Senate in many universities. Subject Boards were formed in each of the different subjects to decide the syllabi and academic requirements. Prof. Sunil Mukhi became the first Dean of Graduate Studies.

Since the inception of the TIFR DU, seventeen batches of students have been admitted and many of those who have graduated with PhD degrees have already established themselves in the scientific community. Several of them already hold prestigious faculty positions in India and abroad. During the last decade, nearly half of the GS students have joined directly after their Bachelor's degrees. These students are getting an early start in high-quality research, for which earlier many of them were going out of the country. TIFR DU now has well developed formal integrated M.Sc.-Ph.D. programmes in most areas of its pursuits. TIFR has established two new Research Centres – ICTS, Bengaluru and TCIS, Hyderabad – over this time, and GS programmes in these Centres have also been established within the same framework as those in the main campus. The UGC and NAAC review committees have commented very favourably on the multi-disciplinary environment that TIFR system offers its researchers and students.

## Mathematics

From the very beginning, Dr. Bhabha's idea of an institution for fundamental research included pure mathematics as one of the areas to be pursued. He recruited two mathematicians – H.W. Levy and D.D. Kosambi as early as 1948. With the arrival of K. Chandrasekharan in 1949, the training of students in mathematics began in earnest. In early fifties, Chandrasekharan persuaded Dr. Bhabha to bifurcate TIFR into two essentially autonomous schools - School of Mathematics and School of Physics.

From 1952, TIFR started advertising for "Research Assistant" positions in mathematics. This was really the recruitment of students to pursue mathematics beyond the Master's degree, and was essentially the start of the graduate school in mathematics. At that time Chandrasekharan and K.G. Ramanathan were the only resource personnel available at TIFR to train mathematics students. However there was a steady stream of distinguished mathematicians visiting TIFR and giving graduate courses of a duration of 2 to 3 months. Among the early visitors were L. Schwarz and C.L. Siegel, who rank among the great mathematicians of the 20th century.

Chandrasekharan set down the interview process for admission to the GS, which is essentially what is followed even today. The committee not only probed the candidate's knowledge, but also gauged his/her understanding of basic concepts and the ability to think. This approach was quite unusual in Indian institutions of the fifties, and has proved to be very successful as is borne out by the internationally famous TIFR mathematics alumni.

By the late fifties, the first year courses had evolved into a standard pattern essentially filling the lacunae left by the weak syllabi of the Master's programmes in mathematics. Students helped in preparation of lecture notes and benefited immensely from this - it ensured that they got to understand the subject in depth and also got the opportunity to interact with some of the finest minds in mathematics. These Lecture Notes enjoy a big reputation in the mathematical community and many are first-rate graduate texts.

The informal way of functioning of the graduate school gave the students a feeling of "belonging to the institution" right from the beginning. Although there was always a degree of insecurity, as a student could be asked to leave if his/her progress was deemed to be unsatisfactory. In 1969, when the School of Physics introduced the formal graduate school, the School of Mathematics also considered the adoption of the formal model but decided against it. It held the view that there was no need to switch to a new paradigm when things seemed to be working quite well.



In the School of Mathematics, Research Assistantship was a 'regular' job albeit on a 5-year contract, extendable in case of promising individuals working towards acquiring wider scholarship. In general the student was expected to find a thesis problem by himself/herself and only occasionally would a faculty member suggest a problem to a student. Most students registered for a degree after they had done some publishable research. The students interacted a great deal with each other and there was as much learning from fellow students as from faculty. There were some notable cases of meritorious students being promoted to the faculty level even before getting a formal doctorate.

In the early seventies, there was also a realisation that apart from topics in pure mathematics, expertise in applied mathematics also needs to be developed in the country. With this objective, a TIFR Centre for Applicable Mathematics was established in 1973, jointly with the Indian Institute of Science, Bangalore. Prof. K.G. Ramanathan heralded the programme and was able to muster support of renowned international experts in the area, particularly in getting them to visit and give courses to students at the Bangalore Centre, and also to have a few promising students further trained at select international centres.

Admission to the Graduate Programme was primarily at the Master's level. However, it was always open to students who had completed B.Sc. as well. Over the years, a significant number of students with B.Sc. have been admitted to the GS programme. The School introduced a "0<sup>th</sup> year" for those entering with only B.Sc. degree, providing these students one extra year for completion of Ph.D., within the framework that had been set under the Programme as a general rule.

In 1984, the School of Mathematics adopted the formal GS pattern set by the School of Physics. This brought in a degree of structure with regard to various activities, and facilitated reaching out to a wider net of potential entrants, as the written tests began to be conducted at various centres across the country. Over the years, the School of Mathematics has produced a good number of Ph.D.s, several of whom have played leading roles in their respective research areas, and in their respective institutions.

## Computer Science

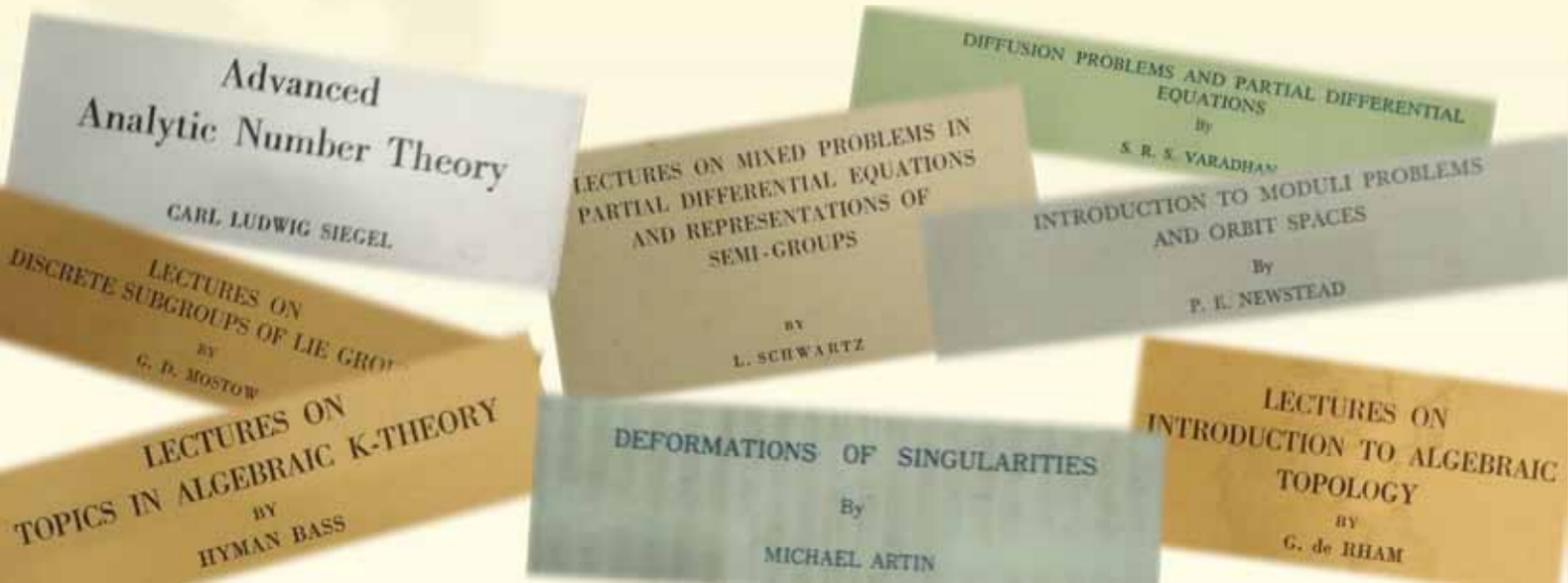
From late 50's to mid-80's, TIFR played a pioneering role in the development of computing technologies in India. It has the distinction of designing India's first indigenous digital computer, TIFRAC, in 1962. It was accorded the status of National Centre for Software Development and Computing Technologies (NCS DCT) in 1974.

From early days, TIFR computer scientists had been organizing advanced courses and workshops. Between 60's and 80's, a generation of scientists and technologists learnt to use computing, and carried out their computations using TIFR resources. Addressing the need for highly trained manpower in advanced computer science, NCS DCT ran a one-year Master's level Diploma in Computing Technologies for over a decade. With the development of the state-of-the-art systems and software, several TIFR engineers as well as full-time graduate students in the School of Physics - with diverse backgrounds spanning physics, maths and engineering - undertook doctoral thesis work in computer science.

UNDP (United Nations Development Program) had recognized the pivotal role of NCS DCT in growing the computing technologies in India. It enabled a galaxy of topmost computer scientists to visit TIFR and offer advanced courses. The lectures by J. Hartmanis in 1965 on switching theory as well as a later course by David Gries on Compiler construction were scribed as TIFR Lecture Notes, and these became invaluable resources. C.A.R. Hoare lectured on his Communicating Processes Theory in 1977, prior to the publication of his historic paper in 1978.

In 1981, TIFR started the *Foundations of Software Technology and Theoretical Computer Science* (FSTTCS) conference. This quickly became the main forum for academic exchange in computer science research in India. The system of UNDP-funded advanced short courses was morphed into week-long pre-FSTTCS workshops. Leading computer scientists lectured at these workshops and a whole generation of students was inspired to carry out their Ph.D. thesis work deriving from these workshops.

In 1985, NCS DCT was spun off as an independent institute named NCST, and TIFR decided to focus mainly on the academic aspects of computing science. With the going out of NCS DCT from TIFR, there was a lull in the graduate studies program. However, TIFR established a Theoretical Computer Science (TCS) group in 1988 with 3 faculty members. It is only since 1990 that a regular induction of Ph.D. students in the computer science program was started through a dedicated nationwide test and interview. This quickly led to an organized set of graduate courses and systematized course requirements.



Recognizing the important role of computer science and technology, and following the recommendations of the Porter review committee, TIFR established a separate School of Technology and Computer Science (STCS) in the year 1997. When TIFR became a deemed university in 2002, a dedicated subject board in Computer, Communication and Systems Sciences was formed to look after the graduate studies activity in STCS.

Complementing the diversity in the faculty, the STCS graduate program attracts students with diverse academic backgrounds. The current set of courses in the graduate program also reflects this diversity, providing exposure and offering flexibility to graduate students to develop a broad background across fields.

The interdisciplinary composition of the School allows students to work on novel conceptual problems arising from the modern day synergy of information, communication and computing technologies driving our current knowledge era. STCS Ph.D. students are regular recipients of prestigious fellowships such as the Google, IBM, Microsoft and TCS Fellowships. The Ph.D.s from STCS have gone on to make their mark, becoming faculties in leading Indian and international universities, and joining R&D centres of leading Industries.

## Biology

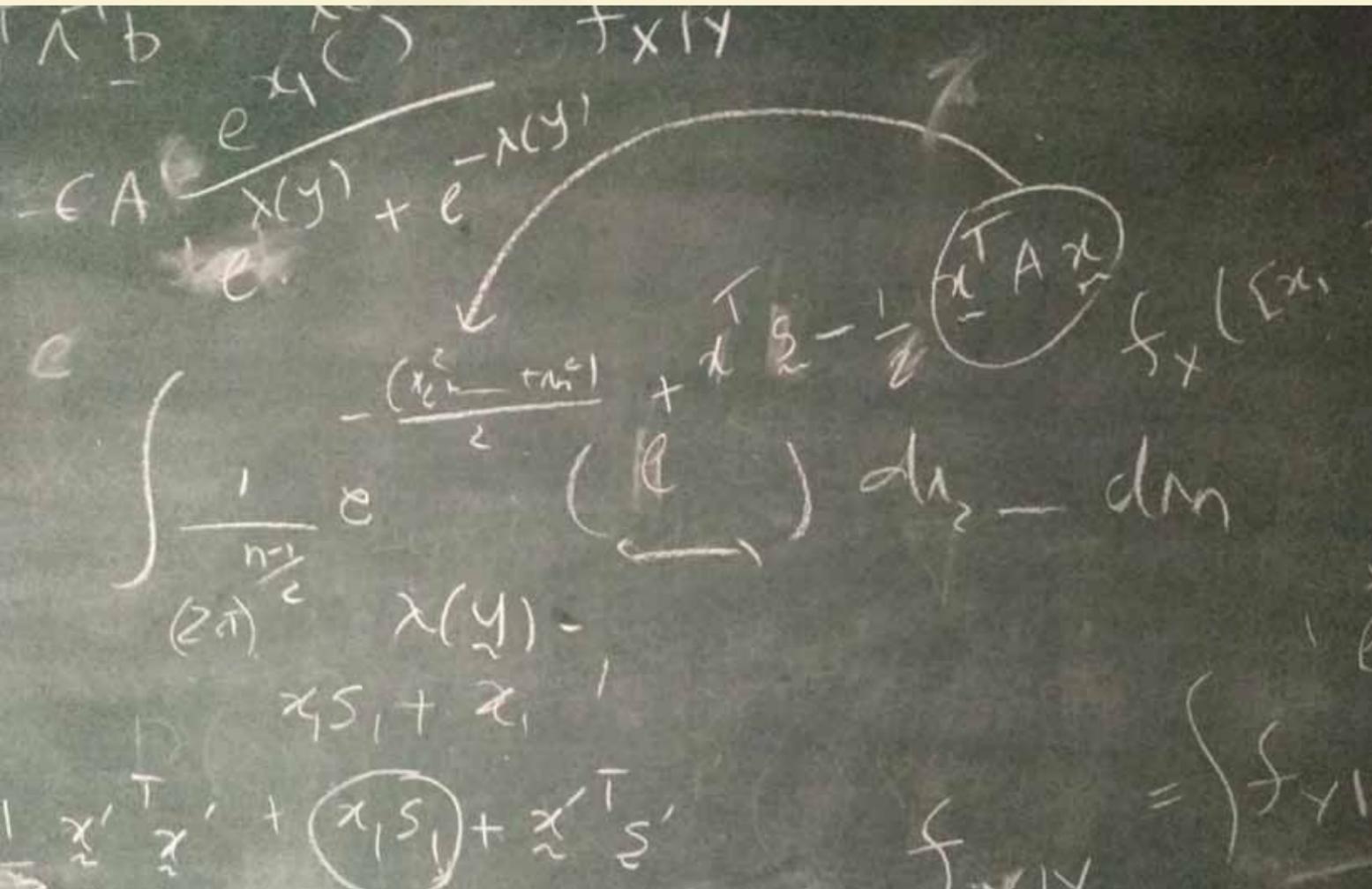
Molecular Biology Unit (MBU) was started in TIFR by Obaid Siddiqi, who was inducted by Dr. Bhabha in 1962. There were about 20 members in MBU by the end of sixties. There were very few students amongst these as Mumbai University did not recognize molecular biology as a separate discipline. Modern Biology did not fit into the traditional Departments such as Botany/Zoology/Biochemistry etc., and eventually in the early seventies, a department of 'Molecular Biology' was created in Mumbai University.

The students in MBU came from diverse backgrounds - chemistry, physics and engineering - and had no formal training in Biology. The idea of bringing up all students to the same level through core courses was not only impractical, but was considered non-essential. Instead, emphasis was laid on reading and topical courses. MBU also organized several international laboratory and theory courses during those two decades. One such course on Microbial Physiology and Genetics held in 1969 inspired P. Babu, a theoretical physicist at TIFR, to move over to Molecular Biology. From 1987, MBU operated a successful stand-alone 3-year M.Sc. Programme, degrees being awarded by Bombay University.

By 1991, National Centre for Biological Sciences at Bangalore was established and MBU in Mumbai was later morphed to the Department of Biological Sciences (DBS). The term 'Molecular Biology', as a form of modern biology envisaged in the sixties and seventies, developed other connotations worldwide with the advent of recombinant DNA methods, and TIFR was back to the broad canopy of 'Biological Sciences'. Formal core courses in Biology were crystallized after TIFR became a Deemed-to-be University. While the biology, chemistry and physics GS programmes are operated by different Subject Boards, the spirit of cross talk amongst students of all disciplines is still maintained.

The NCBS GS programme started with M.K. Mathew and Jayant Udgaonkar involved in formulating policy. Formal coursework requirements represented a big change: earlier it had not been considered necessary as the incoming students were assumed to be adequately trained. The first few batches of students continued to get degrees with Bombay University. Later, the NCBS students also started registering with Mysore University, and with Manipal University. This continued till TIFR was granted the Deemed-to-be-University status.

NCBS and DBS were responsible for conducting the TIFR Biology Exam, and would earlier conduct joint interviews. This exam has now become the Joint Graduate Entrance Examination in Biology and Integrated Life Sciences (JGEEBILS), which is used by over 20 institutions across India for their graduate recruitment. In 2004, NCBS partnered with the Centre for Wildlife Studies (CWS) to launch the unique Masters Programme in Wildlife Biology and Conservation, a field-research-intensive course which admits 15 students every two years.



## Chemistry

The Graduate School of chemistry as we see it today has no resemblance to what was there in the early seventies. The Graduate School of TIFR at that time was exclusively centred on physics. There was no graduate course structured for chemistry graduates. Graduate students coming with a chemistry degree were expected to think and behave like physics students and take physics graduate courses.

This mindset of labelling chemistry as 'applied physics' was clearly visible right from the selection process. Chemistry students were evaluated along with physics students by the same selection committee and by similar procedures. Although this might sound quite unreasonable now, it served the requirements of research in the Chemical Physics Group of the seventies. The main emphasis of research in the Chemical Physics Group was physical understanding of chemical and biological processes and hence a strong training in physics was quite useful. However, the lack of higher level training in chemistry and biophysical chemistry was an unwelcome state of affairs.

The transition from Chemical Physics to Physical Chemistry/Molecular Biophysics accelerated by the late seventies. The graduate course on Molecular Biophysics offered by Girjesh Govil was one of the early ones addressed towards chemistry graduates. However, maturation of the chemistry graduate school having its own set of courses had to wait for another decade.

By the mid-eighties, the graduate school training had to catch up with the changing trend of chemistry towards material chemistry. The rigor and the comprehensive nature of the Physics GS program inspired the Chemistry program. The Chemistry GS initiated several courses with a strong emphasis on quantitative physical chemistry. Courses such as Quantum Chemistry, Mathematical Methods, Chemical Kinetics/Dynamics, Molecular Biophysics, NMR spectroscopy were initiated. By the late eighties, the composition of the faculty also transitioned from physics to physical chemistry. This helped in formulating and sustaining the Graduate School.

The turn of the millennia brought another major change to the Chemistry GS. Once again, this was the result of a shift in focus of research activities in the Department of Chemical Sciences (DCS) as the Chemical Physics Group was renamed. The DCS initiated a substantial programme on materials chemistry based on synthetic approaches. The GS programme began including this flavour. This completed the transition from physics-based research to chemistry and biophysical chemistry-based programmes.

## Science Education

The graduate programme in science education started at HBCSE (TIFR) in 1999, only a few years before TIFR was granted the status of a Deemed-to-be University by the UGC in 2002. However, even earlier there was a fairly vibrant activity of mutual learning and teaching among HBCSE staff members as well as of research in this emerging new field.

From its inception in 1974 as a unit of TIFR, it was recognized that field activity at the grassroots level was indispensable for any genuine scholarship and research in science education. At an early stage of HBCSE, research in the field was embedded in a rural educational intervention being carried out by the Centre. The University of Pune offered to recognize this field for the degree of Ph.D. and the first doctoral thesis of the Centre came out in 1981, the year HBCSE became more formally an integral part of TIFR, aided by DAE.

The next decade saw much informal learning and teaching among staff members in field trips, seminars and joint reading sessions, though occasionally some courses were also offered. The Centre's research focused mainly on investigating student learning hurdles in school science and mathematics, with particular emphasis on the socioeconomically disadvantaged groups. The Ph.D. theses that came out during 1987 to 1995 reflected this focus.

In 1992, HBCSE moved to its present campus, and the improved facilities spurred its growth. Soon, the higher education stage (senior secondary and undergraduate) was added to its profile of research, materials and orientation. Activities that led eventually to its graduate school in science education started in earnest. To orient each other of global trends in the field, courses of varying durations were voluntarily offered by HBCSE members on such topics as learning theories, cognitive development, sociology of education, philosophy of science, history of science, research methods in science education, and so on. In due course, the University of Mumbai also recognized this field for the award of a Ph.D. degree. By 1999, HBCSE had become a National Centre of TIFR with its own Faculty in the field of science education, and a formal graduate programme was inaugurated.

Subsequent to TIFR becoming a Deemed-to-be University, the Institute constituted a separate Subject Board in Science Education (as it did for other disciplines) and the graduate programme at HBCSE got further institutionalized. The norms and procedures of the graduate programme were brought on par with the rest of TIFR.

HBCSE's graduate programme in science education covers a whole range of dimensions of science and mathematics education (cognitive, pedagogical, epistemological and socio-cultural) spanning the primary through secondary to the undergraduate stages. The programme includes a compulsory component of 'field work'. The graduate courses aim to give a broad exposure to the disciplines of cognitive science, education, history and philosophy of science, which inform any serious work in the field at any stage of education. The course programme also emphasizes methodological aspects of research in science education, the techniques of qualitative and quantitative research, and so on.

To conclude, from modest beginnings, the Graduate programme at HBCSE has come a long way. Still, the extraordinary diversity and novelty of the programme requires that it be continually reviewed and its foci debated to ensure that the research output of the Centre continues to be significant in terms of intellectual depth and educational relevance.

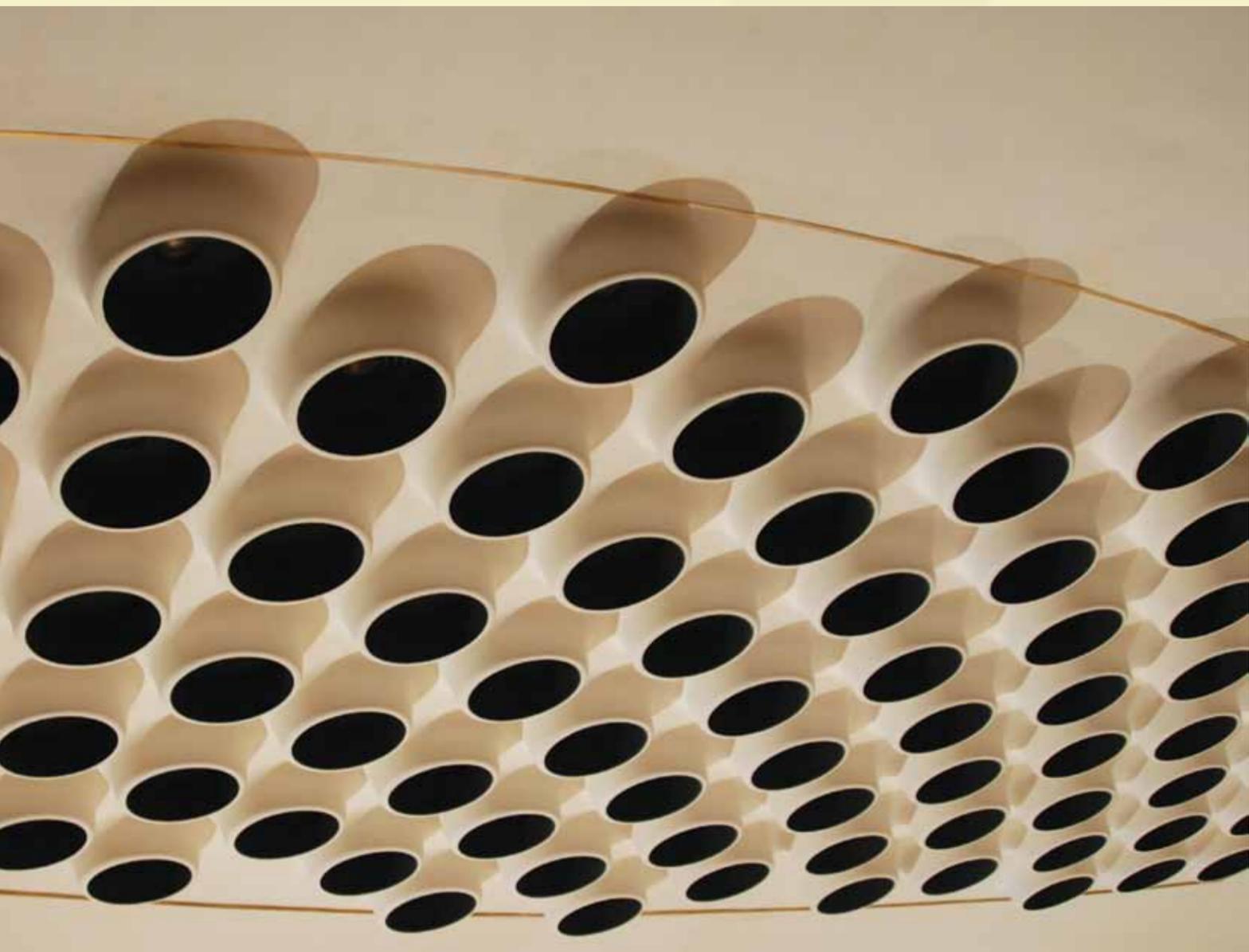
## Radio Astrophysics

The Graduate School at the National Centre for Radio Astrophysics (NCRA) was set up in 1991, in collaboration with the neighbouring Inter-University Centre for Astronomy and Astrophysics (IUCAA), a collaboration that continues today. Prior to this, students with guides in the TIFR Radio Astronomy Group did their course work (if any) either in the TIFR (Mumbai) GS, or in the Joint Astronomy Programme, Indian Institute of Science. NCRA was formally recognized by the University of Pune as a post-graduate centre for research in Physics and Electronics in October 1992. For the first decade, NCRA students registered for their Ph.D. degrees at the University of Pune. Since 2002, NCRA students have registered with TIFR DU.

Students in the NCRA Graduate School came from a wide range of backgrounds and a significant fraction of students, especially in the first decade, had an engineering degree. Some of these students joined NCRA as Research Associates, earning their Ph.D. degree en passant, while also working on the development and the debugging of the GMRT. From 1991 to 2013, students with both M.Sc. and B.Tech. or B.E. qualifying degree attended the NCRA Graduate School immediately after joining NCRA. Students with M.Sc. qualifying degree continued towards a Ph.D. degree after completing the Graduate School courses and projects. Students with an engineering degree obtained M.Sc. degree prior to registering for the Ph.D. degree.

A new route to the NCRA Graduate School began in 2013, when NCRA began an Integrated Ph.D. programme. Since 2013, students with either a 3-year B.Sc. degree or an engineering degree join NCRA's Integrated M.Sc.-Ph.D. programme, carrying out an initial year of M.Sc.-level course work at either the University of Pune or the Indian Institute of Science Education and Research (Pune), after which they join the NCRA Graduate School.

*(The above write-up on the development of graduate school is based on the inputs provided by Arun Grover, S.S. Jha, Sunil Mukhi, N. Mukunda, T. Padmanabhan, G. Rajasekaran, S. Ramakrishnan, Probir Roy, M.S. Raghunathan, S.G. Dani, G. Krishnamoorthy, Gaiti Hasan, M.K. Mathew, Shobhona Sharma, Mukund Thattai, Mathai Joseph, Sandeep Juneja, Paritosh Pandya, Jayaram Chengalur, Nissim Kanekar, and Arvind Kumar)*



## Growing Science in Postcolonial India: The Historical Context of the TIFR Graduate School

Over half a century ago, in what was to become the last speech, Homi Bhabha spoke about the slow and challenging process of “growing science” in India. The culture of modern science was not intrinsic to India and needed to be transplanted from the West. The impetus to make science an organised national activity came after independence, and, as Bhabha acknowledged, with Nehru’s support. Historically, modern scientific development existed only in relation to imperial expansion in the nineteenth and early twentieth centuries; and Nehru saw scientific development as a way of embracing modernity. At the Tata Institute of Fundamental Research (TIFR), the training programme for young researchers evolved out of the same philosophy.

TIFR started out by hiring research workers with M.Sc. degrees, in an era when very few Indian universities trained students in research. The young researchers attended lecture courses offered by faculty and also by eminent visiting scientists. Young researchers were assigned the responsibility of taking down lecture notes, thus enabling them to work closely with the scientists as well as absorb and learn their work. Courses were designed that addressed the basic lacunae in the knowledge of students coming from a university system where many advanced topics were not taught. Unlike universities at that time, the library at TIFR was rich in resources, books, journals and pre-prints, giving students access to latest research. Peer learning was important for all research workers.

The Ph.D. degree was awarded by the University of Bombay which at that point, did not require coursework. However, from 1964 onwards TIFR began to organise regular graduate courses in order to make the training more systematic and broad-based. In 1969, the Graduate Programme was formalised.

Since the mid-1980s, TIFR has undergone unprecedented transformation driven by several factors – by Bhabha’s foundational legacy, by shifts in government policy from science and technology to science and innovation, by the dramatic increase in the number of students, by the emergence of new disciplines and interdisciplinary research, by the creation of competing institutions and the shifts in balance between them and by TIFR’s move away from the university system to becoming a degree-granting institution. As the Graduate Programme completes fifty years, it seems an opportune moment to reflect on the changing nature of the programme, the context of its first articulation, the upheavals it has endured and the framework within which it was redesigned.

**Dr. Indira Chowdhury,**  
*Srishti Institute of Art, Design, and Technology*  
*(Former Head, Arts and Archives Cell, TIFR)*

## Reminiscences



*We had an overwhelmingly positive response from alumni who were either students in the GS, or were involved in the development of the GS. Due to the space constraints, only excerpts from many of their write-ups could be included. We thank all the contributors, and apologize for any omissions.*

*– Editors*



## From those at the Helm

### **Probir Roy (TIFR 1972-2007)**

*Former Professor and Chair, Graduate Study Committee (Group Committee V)*

I remember teaching a couple of Graduate School courses during the seventies. ... Towards the end of the seventies, the Graduate School activities dwindled down a bit. Theorists in the faculty gave a small number of basic courses to theory students while experimentalists gave their students highly specialized training focused on their own research.

By 1982, there was a general realization at the Institute that the above state of affairs was not optimal. In 1983 the Graduate School was revived, with BMU back from the UGC, and myself as the Course Director. The course structure was divided into Core and Topical courses, and a credit system was evolved. The idea of Projects was formally incorporated. We started the Visiting Students Research Program (VSRP) in 1983, with myself as the first VSRP coordinator. It was a great success, acquiring national fame and being repeated every year since then till today.

### **Sunil Mukhi (TIFR 1984-2014)**

*Professor, IISER Pune; Former (first) Dean, Graduate Studies, TIFR*

When I joined in 1984, there was a stable pattern of graduate courses... the courses were conducted somewhat informally ... Personally I found this very enjoyable because classes were small and all one's time was spent on actually teaching and communicating with students. ... I became a member of Group Committee V, but this only had recommending power and all major decisions about rules and procedures were taken by the Physics Faculty. But being a mere Reader, I was not a part of the Faculty and not allowed to attend its meetings...

The degree would be issued by Bombay University and one had to be an approved guide with them in order to supervise a student. But I could register only after I became a Reader. ... and it took over a year for the application to be approved... The process of getting reports and fixing up a thesis defence was slow and time-consuming. ... The system worked, but was not particularly suited to the needs of TIFR. ... Slowly it became clear that working through Bombay University was not practical. It was decided in a high-level Committee that TIFR should apply to be a Deemed University.

In 2002, when TIFR became Deemed-to-be University, the Director asked me to be the first Dean of Graduate Studies, but then it took many months before this position was approved by the Council of Management. In the meanwhile, Bombay University had stopped handling theses from TIFR. So for a while everything was blocked and there was some anger from both faculty and students. (Some even called it a “Doomed University”). With a skeleton staff of one person (Mohan Kakade), we had to work out procedures for the entire Academic programme, starting from the decision-making bodies. I remember sitting up late at night trying to design a Ph.D. degree certificate and wondering whether one should use a modern or traditional font!

Deemed University gave more autonomy to the Subject Boards. ... We tried to administer as fast as could be done without compromising on academic quality. For example we would give a provisional degree certificate on the day after the viva (sometimes on the same day if needed). ...in general, both guides and students were appreciative of our simplified and minimally bureaucratic procedures.



## From the Alumni

### **Padmanabhan Babu (TIFR 1961-1989)**

*Former Professor, TIFR*

I joined TIFR after Training School, and started with Yash Pal on Cosmic Rays. Soon I moved on into studies of symmetries in Particle Physics with Udgaonkar as my mentor and did my Ph.D. After a stint with Gell-Mann as Post Doc at Caltech, I joined Molecular Biology Unit created by Siddiqi.

From 1960 onwards, 3 approaches to graduate program at TIFR emerged. The first was the selection of bright physics trainees mostly from the Training School. They joined different well known physics departments in USA and returned after their Ph.D.. These scientists were to be part of the teaching staff for Physics graduate school. ... The second approach was taken by MBU. Siddiqi was keen on getting scientists with varied backgrounds such as Physics, Chemistry, Biochemistry, Genetics etc. From 1973 I was part of the team in setting up the graduate program in Molecular Biology. ... The 3rd and a fascinating approach was taken by Mathematicians. They seemed to have a special knack in spotting and nurturing exceedingly bright young mathematic students right out of college and building up a truly world class group of mathematicians.

### **Sarbani Basu (GS 1988)**

*Chair, Department of Astronomy, Yale University*

I was a part of the second cohort of students of the TIFR-Pune University M.Sc. Physics programme in the second half of the 1980s. It seemed quite natural after that to continue to do a Ph.D. at TIFR. Those were interesting days filled with discussions of physics over late night tea in the canteen. We did spend a lot of time in the Institute, among other reasons to escape the heat and humidity outside.

The late 80s and early 90s was a difficult time to be a graduate student in India. The economy had not been liberalized. Text books were prohibitively expensive, and travel was frowned upon. Travel to conferences was considered a luxury rather than the networking opportunity it was and still is. Consequently, we did not make the personal connections with the broader research community. And there was both overt and covert sexism to deal with. What is etched on my mind that there was a couple, both full professors, working in nuclear physics, but while the man was always Prof. D., the woman was merely Mrs. D..

TIFR and my mentors did open quite a few doors for me. And then I got a chance to work at the Institute for Advanced Study in Princeton, which led to Yale where I have worked since January 2000.

**Ramanath Cowsik (TIFR 1961-2003)**

*Director, McDonnell Center for the Space Sciences, Washington U. St. Louis, USA*

When I joined, Husain's mural was not there, nor was either the East or the West Canteen, and not all offices had furniture. But most importantly neither the front entrance, nor the library door had locks on them; they were always open.

TIFR has been the alma mater to many great mathematicians and scientists, and many are still being nurtured by it. Many fine institutions have been born in its wake, and are modelled after it. I am forever beholden to Dr. Homi Bhabha for founding the institution and infusing it with an atmosphere that stimulates scientific enquiry. May this spirit encourage and sustain generations of scientists yet to come.

**Mahananda Dasgupta (GS 1986)**

*Australian Laurate Fellow, Australian National University, Canberra*

The perfectly manicured lawns, the spectacular entrance, stunning art, the library with amazing views and the immaculately-polished elevators all filled me with a sense of awe, because from August 1986, this would be my home - for the next five and half years! The assignments and projects that pushed us hard were a baptism of fire. Like students before us, we complained about our "tough" lives that required us to work till the early hours of the morning. (Professor Jha's 9.00 am deadlines are etched in my memory).

I realise now that it was not the content that was critical – the key was the training we received in how to approach a problem, clarity of thought, resilience, independence, conveying ideas succinctly, making presentations and fielding questions (from the left field, as student seminars were fair game). These foundations were critical to our future lives as scientists, teachers, innovators and life-long learners.

The atmosphere was definitely competitive, and pushed everyone to do their best. This pressure would have been hard to take without the very well-knit and extremely supportive group of students. The "can-do" attitude fostered by TIFR, irrespective of gender, held me in good stead as a woman in science (though sadly, women faculty in TIFR were very few). Another strong influence was the environment, which demonstrated to us that life is not only about science – music recitals, dance programs, classic movies shown by the film club, the photography club and weekend hiking all contributed to giving us the confidence to go out into the world and to hold one's own – and this is what we have done.

**Prabuddha Ganguly (GS 1971)**

*CEO, Vision-IPR, and Visiting Professor, Rajiv Gandhi School of IPR, IIT Kharagpur*

Nostalgia engulfs me with fondness, as I recall my golden days in TIFR from 1971 to 1977, when my mind was in a state of Brownian motion, exploring what all to do that would prepare and crystallise me to meet the future with boldness, courage, pride and commitment, equipped with a fertile mind to continually & vibrantly learn, coupled with an urge to meaningfully apply those learnings to make a difference to me and the society in which we live. The graduate school in TIFR was then a unique democratic melting pot of thoughts without bounds, state of art knowledge and debates on a spectrum of subjects. Every moment promoted free thinking, openness, comradery and a sense of purpose. In addition to excellence in academics, TIFR those days was also a breeding ground for many socially relevant activities nucleated by thought-leaders and visionaries who were able to blend the best in academics with effective diffusion of scientific thinking beyond the walls of TIFR, permeating into various schools, colleges & institutions, where students and teachers were not as privileged as we were in the TIFR Graduate School.

This is the pulsating TIFR I recall that prepared me to launch into the future. Life has been interesting ever since. Returning to India after post-doctoral experience, joining BARC as visiting scientist, transiting into industry for the next two decades in diverse managerial functions, deep diving as an entrepreneur in the field of Intellectual Property Rights & innovation during the last two decades with concurrent involvement as a consultant in national & international institutions, and contributing to teaching & research in academic institutions fills me with the joy of living and gratitude to TIFR for having prepared me so proficiently to face the unknown.

**Arun Grover (GS1972, TIFR 1972-2019)**

*Former VC, Panjab University, Chandigarh*

I joined Physics Graduate School in 1972, when the new TIFR hostel had not completed even one year. We received core courses from a new set of inexperienced teachers, as all the theory group regulars had given one course or the other during the first three years of GS, and there were many complaints. A redeeming happening was that Prof. Jayant Narlikar had joined and he offered an elective course on Relativity and Cosmology for our seniors, but we all first year students enrolled for it and completed it.

A high point of our second year stay was an exclusive three hour long session with Nobel Laureate Felix Bloch in January 1974, as he visited to participate in International Conference on Magnetic Resonance. Our batch-mate Chanchal Mitra had hijacked him into the first year students' room. Another batch-mate of ours, Bajji (R. Ramachandran), got the Amateur Music Association "AMA" and the movie club "Images" going. The

football ground also came about via a 'Shramdan' campaign to clear the rubble dumped there, Prof. B.V. Sreekantan generously stepped in to provide institute support to get a ground prepared.

A sore point, however, was the non-enhancement in the honorarium for Visiting Members since its inception in 1962. It took lots of efforts to get it enhanced from Rs 450 to Rs 550 first, and then to Rs. 650 as the Research Trainees were inducted parallel to the Research Scholars in 1976. Post-Doctoral Fellowships abroad had become scarce in mid-1970s, there was a lot anxiety amongst Ph.Ds. graduating from TIFR. Luckily, the Electronics Commission, ONGC and Space Applications Centre inducted a significant number of them. Prof. Sreekantan also took initiative to induct fresh Ph.Ds. as Research Associates in several departments of TIFR.

### **Subhendu Guha (TIFR 1968-1982)**

*Photovoltaic Scientist, USA*

I joined TIFR in 1968. The Graduate School started within a year. TIFR used to attract very good students from all over the country. The purpose of the graduate school was to prepare them for research activities. The students were encouraged to interact with different research groups so that they can decide which activity excites them the most. This is an excellent model because the students could start research with an educated mind.

A major part of our activities focused on amorphous semiconductors. It was exciting to contribute to a field where the physics was just emerging. The other activities were in III-V semiconductors and silicon devices. We worked on both material science and device physics. I certainly benefited from interacting with the students, many of whom have established themselves as leaders in their fields all over the world. Excellence in what we do was our primary motivation. Based on what I hear, TIFR is still maintaining that excellent tradition.

### **Ramakrishna Hosur (GS 1973)**

*Padma Shri, Former Director, Centre for Excellence in Basic Sciences, Mumbai*

When the graduate school started in 1969, it started in a very modest way admitting only a handful of students for the Ph.D. programme. For example, in the year I joined TIFR in 1973 – we used to be called as 'Visiting Members' in those days – only 4 students were admitted in the entire school of physics (chemical science was a part of the school of physics), 2 in the area of biological science and about 6 in mathematics. All had to go through graduate courses, which brought them up to the level required for pursuing research. 'Flexibility to nurture creativity' was the hall mark of the 'graduate school'.

These principles continued to shape-up my career ... The Graduate School has grown from strength to strength over the years and today TIFR admits more than 150 students every year, all branches put together, and it is satisfying to note that the same spirit of quality and creativity continues to flourish. Clearly, TIFR graduate school has demonstrated a model which needs to be emulated in all the Universities and academic institutions.

### **Ajit Kembhavi (GS 1972)**

*Former Director, IUCAA, Pune*

I attended the graduate school during 1972-74. Those were early days in which the structure of the graduate courses was undergoing various changes, not all of which were appreciated by the scholars, which led to a number of arguments with the seniors. I remember a time when some of us were venting our anger on as calm and peaceful a person as BMU. The arguments and discussions brought close bonding in the rather large batch scholars, leading to friendships which have lasted for close to 50 years.

I still remember the course I took in the second year on general relativity, given by Jayant Narlikar. The led to my becoming his student, and my later career in TIFR and IUCAA. So graduate schools do have very long term consequences.

### **Vidhya Krishnamurthy (GS 1987)**

*Head of Systems Engineering, Varian Medical Systems*

When I walked into TIFR, the fall of 1987, I was as intimidated as I had been during my interview when renowned scientists were poised to quiz me! I was in awe ... The first one and a half years were peppered with navigation around some really hard courses, some not so much ... understanding my way around the lab, around the fundamentals of research, discussions that went late into the night, tea and toast in the west canteen, many a walks along the rock face and did I say some very hard courses? Amidst said madness I decided to become an experimental physicist in the Atomic and Molecular Physics Group.

As an experimentalist whose advisor insisted on instrumentation, I learnt what a development cycle looks like, the importance of creativity, grit and resourcefulness, identifying the tall pole in the tent and designing experiments to get to root cause. As my experiments started yielding results, I struck collaborations outside my group to develop models that could explain some of our results. I did not know it then, but these experiences became invaluable to me later in life.

As a boarder in Brahmagupta I had the best of times, in discussion on topics ranging from politics to biology, physics, music just about anything... There was the movie club which introduced me to very interesting and bizarre movies, and the hiking expeditions that left at 2 am to climb hills without paths. The fake promise of 'batata-vada' around the corner to keep us going when we got lost, every single time! The friendships forged then have stood the test of time.

#### **Satya Majumdar (GS 1987)**

*Director of Research (CNRS), University of Orsay, France*

I joined TIFR as a graduate student in 1987 September and finished my Ph.D in 1992 in the department of theoretical physics with Prof. Deepak Dhar. I still count these 5 years in TIFR graduate school as one of the best phases of my life, both scientifically and socially. Those days we were about only 60 graduate students in TIFR, all living in the Brahmagupta hostel. What was really unique about TIFR was that students across faculties (physics, mathematics, chemistry, biology and computer science) were interacting with each other, and also with the faculty. For the first time in my life I was calling my seniors by their first names!

I learnt enormously from my friends and teachers in the graduate school, not just about science, but about books, films, history, music, games, hiking in the western ghats and many other things, including hearing incredibly funny stories about our seniors and contemporaries! It was an amazingly enriching experience for 5 years, scientifically as well as culturally, that I cherish till today. TIFR graduate school made us what we are today, and all of us were and are extremely proud about it.

#### **Jayant Narlikar (TIFR 1972-1988)**

*Former Director, IUCAA Pune*

I usually participated in the annual interviews for recruiting new research scholars, and lectured in the graduate school on specific courses. My impression was that of the entire Physics Faculty only a handful came forward to lecture. That was unfortunate since indeed it is well known that teaching and research going hand in hand are more productive. I also recall that because of shortage of manpower the Pune University Physics interaction with TIFR had to discontinue.

... One should also try to encourage problem solving amongst the graduates. I recall lecturing at a Bangalore summer school around 1975, when over the weekend a trip was arranged to Ooty for the Radio Telescope. On the bus to Ooty, I recall generating

discussions on various problems. Rajaram, Saikia, Shri Kulkarni and several others took part. ... several of them remember that bus ride.

I wish the Graduate School a happy future and excellent teachers.

#### **Ranganath Navalgund (GS 1970)**

*Former Director, Space Application Centre, Ahmedabad*

Looking back at the mature or otherwise age of seventy-one, the period I spent at TIFR, 1970 to 77, has been remarkable for many reasons. The liberal academic environment, interactions with the very talented peers in science, spending long hours with friends and colleagues with sharp intellects in the laboratory, in walks along the sea coast, in the Western and East canteens and at the nearby hostel, and of course at the 'Colaba Causeway' sometimes, broadened my horizon and moulded my personality. We were a large batch of twenty-two graduate students, each, a very bright student from different parts of the country. This brought a reality check for each one of us, as well as life-long friendships. Doctoral degree obtained at TIFR, a brand in itself, has stood in good stead in my professional career.

I must also share at least two instances of admonishing that I received during my stay at TIFR; one from Mr Putran, the Registrar, for playing tennis ball cricket along with fellow graduate students on the pristine, well-manicured green lawns of the institute and the other from Prof Daniel, Dean of the Physics Faculty for broaching the subject of increase in our honorarium, when everyone else got a raise in their salaries (I happened to be the Convener of Graduate Students, courtesy Prof. Jha).

When I joined the Space Applications Centre (Indian Space Research Organisation) at Ahmedabad immediately after completing my Ph.D. in 1977, then headed by Prof. Yash Pal, a TIFRite. I thought, I am leaving behind the Physics that I learnt. I had chosen this assignment over the usual path of going abroad on a postdoctoral fellowship. However, the research environment, liberal attitudes and the excitement of challenges of space activities just beginning in India, spurred me on; the broad-level of training that I had at TIFR, academically and aptitude-wise, greatly helped. Forty years of my professional contributions in ISRO, in general, and pioneering contributions to the field of spaceborne remote sensing of the earth and Chandrayaan 1, in particular, are a testimony to my schooling at TIFR.

### **G. Rajasekaran (TIFR 1958-1976)**

*Former member, TIFR Theory Group*

After one year as a trainee in the first batch of the AEET (now BARC) Training School, I joined TIFR Theory Group in 1958. My inward bound journey in TIFR took me to Quantum Mechanics, Nuclear Physics and finally Quantum Field Theory. After listening to L.K. Pandit's beautiful lectures which consolidated my understanding of QFT, I reached the destination of my journey.

I was working with S.N. Biswas. One day he told me that I must go to USA for Ph.D. I did not want to go; I did not think Ph.D. was necessary for research. Those days Ph.D. was a rarity. But Udgaonkar, Biswas and M.G.K. Menon bought the tickets, got the passport and visa and packed me up and sent me to University of Chicago to work with R.H. Dalitz for my Ph.D. After two years in Chicago and one year in Oxford, I returned to TIFR.

By 1964, TIFR had shifted to new buildings in Navy Nagar, Colaba from their temporary premises in Old Yacht Club near Gate Way of India. Bhabha planned the new building in such a grand scale that it was sometimes called the Tajmahal of Homi Jahangir Bhabha. I started teaching to graduate students on my return in 1964, although the formal Graduate School started in 1969.

### **N. Ratnashree (GS 1986)**

*Director, Nehru Planetarium, New Delhi*

When I appeared in the interviews for TIFR Graduate School, while going from one interview committee to the next one, I saw the sea at full tide from the fourth floor common area windows, and told myself repeatedly - I have to get admission here for Ph.D., I HAVE TO.

My love for the TIFR campus with its proximity to the sea has remained to date. It was not really just that (frivolous?) reason why I felt I had to join TIFR - I had an interest in Astrophysics from my school days, and everything encountered at TIFR from the first introduction, was awe-inspiring. Graduate School went by in a blur of courses and assignments undertaken, which may have seemed intimidating but for the wonderful camaraderie and support from so many fellow students, something of which continues in life. I had a very strong interest in certain areas of Astrophysics by that time, and would have had opted for specific courses geared in that direction, if they had been available. I did, however, enjoy the condensed matter oriented courses then available.

Jumping from courses and assignments to the nitty-gritty of thesis work was a shift different from my initial conception of it - it was energetic but, with some chaos. My six years at TIFR, certainly facilitated my later meanderings in interdisciplinary creative channels.

### **Amit Roy (TIFR 1968-1990)**

*Former Director, Inter-University Accelerator Centre, New Delhi*

I joined TIFR as a PhD student in 1968, while the formal graduate school was taking shape and there was a lot of experimentation on the courses. We had to take courses in Astrophysics, Geophysics and Molecular biology in addition to the usual ones in Physics. But the atmosphere was very informal, thoroughly academic, and there would be animated discussions on physics topics in the west canteen. Attending the Wednesday Colloquium was a must and that really helped to widen our vision.

Couple of incidents that occurred during my early days, signifies to me some of the values TIFR stands for. A few months after I joined as a student, during breakfast in the West canteen one of my seniors joined at the table and asked me what I was working on. I casually remarked that it was nothing interesting. He suddenly became serious and snapped, "why the hell are you doing something if you don't find it interesting?" That completely changed my approach to research. In another incident, my thesis guide, Prof. S.K. Bhattacharjee, asked me to delete his name from my very first paper, as he did not think he had contributed enough to the work. That for me was an indelible lesson in intellectual honesty.

TIFR made me self-reliant, allowed me to ignore hierarchies, and taught me the value of a work-centred administration which I found valuable in my later role as a science administrator.

### **Subir Sarkar (GS 1974)**

*Head, Particle Theory Group, University of Oxford*

It was all such a long time ago ... I recall a written examination and an interview. The real challenge was getting to TIFR given that George Fernandes had called a national rail strike that summer. I managed to get a train from Kharagpur as far as Nasik and then had to come by ST bus the rest of the way, and find my way to Colaba in the big city. Somehow when one is young all these things work out somehow!

I recollect a story (probably apocryphal!) that at the interview they would ask a trick question, the answer to which would determine which School (Mathematics, Physics or Biology) you would be assigned to. The question was: "If you are in a Casino and the roulette wheel comes up red 10 times in a row - what would you bet on the 11th time?" If you answer "Well the odds are still 1/2 and 1/2 for red and black" then you are clearly a mathematician. If however you say "The wheel is clearly biased - it will come up red again" then you are destined to be a physicist. But if you think "It is about time the wheel comes up black" then you must be a biologist! I got into physics.

### **Sriram Shastry (GS 1970)**

*Distinguished Professor, Univ. of California, Santa Cruz*

I recall being overwhelmed by the excellence of the faculty, the library and the quality of fellow students. The lack of a hostel forced four of us to stay in difficult conditions at the Old Yacht Club. The crowding did have a positive result, the students became so close to each other that ideas of mutual competition were hard to sustain, and cooperation became natural. I believe that I learnt more from my classmates than at any other time in my career.

The assignments and tests could be very tough indeed. One survived only by discussions with other students. Finally a variety of sports, tennis in my case, helped forge friendships across disciplines and melt formal boundaries between eminent faculty and young students.

### **Shahid Siddiqui (GS 1972)**

*Director, Program in Human Genetics, U Q University, Saudi Arabia*

After studying M.Sc. in biochemistry, Aligarh Muslim University, in 1971, I joined TIFR in MBU. Entering TIFR campus ushers the vision of Homi Bhabha: synergism of the best in arts and sciences. We interacted with pioneers in modern biology – Luigi Gorini. Anna Marie Torianni, Sydney Brenner, C. Holt, and many others. The faculty was diverse and was led by Siddiqui – a dedicated scientist and teacher par excellence. The atmosphere was charged as the secret of Central Dogma (The pathway of DNA to RNA and protein synthesis) were being investigated, and the big riddle of developmental biology had arrived. This was the B.C. era (Before Cloning !)

I joined P. Babu in pursuing biochemical and developmental genetics of *C. Elegans*.... Later Babu left working on it, but I continued working with worms and used airmail letters (no internet) to correspond with John Sulston and Jonathan Hodgkins at Cambridge.

TIFR can completely transform a student and has been a pedestal to launch many impressive careers in science.

### **Parveen Sinclair (GS 1978)**

*Professor, Indira Gandhi National Open University  
Former Director, NCERT, New Delhi*

It was the summer of 1978. I applied to the School of Mathematics, and was called for an interview. When I was offered a place here, I didn't even realise how special an opportunity this was for a mathematics lover. The easy camaraderie between the new entrants and the seasoned mathematicians, many math chats over tea, seminars, coursework, great library collection, etc. helped us to become part of the creative environment built and nurtured here. And we matured mathematically, understanding what "good mathematics" is.

In the decade I spent at TIFR as Research Assistant and Associate, I interacted with several people from other universities and institutes, both Indian and foreign. It was clear that the TIFR-like academic environment needed to be developed in other places in India. This is what I have tried to do, in my limited way, ever since I moved to my current university, IGNOU. Of course there were highs and lows at TIFR, as in other places, but what matters is the quality of the learning support one can give, and get, from others. This is regardless of mathematics. This is a culture - a democratic academic environment, largely non-hierarchical, autonomy in academic decisions, and not a top-down approach. I hope this does happen, with more people from TIFR helping to develop such an environment in other institutions in India.

### **Gurinder Pal Singh (GS 1971)**

*Retd Principal Engineer, Hitachi General Storage Technologies, San Jose, USA and  
Chief Technical Advisor, Future Hi-Tech Batteries Ltd, Punjab*

The time I spent at TIFR (1971-78) is etched in my memory as the most enjoyable, productive and interesting time. Besides TIFR, I had chance to work at two other great research institutes, namely Max Planck Institute for Solid State Research in Stuttgart Germany and IBM's Almaden Research Center in San Jose, California; but the TIFR time stands out as unique.

One of the main reasons was that TIFR provided me the company of exceptionally bright people who were easily accessible, open and passionate about the enquiry they were pursuing. I want to thank my Ph.D. guide Dr. B.K. Basu for allowing me to choose what I wanted to research on and how and supported me all the way. Our lab facilities were modest, but dedication of engineers like Mr. M.J. Mehta, Mr. Apte and availability of excellent facilities like glass blowing shop, model shop etc. filled the gaps. Another factor was the beautiful art studded environment that Dr. Homi Bhabha had designed for this research centre. Walks on the sea shore, while discussing with Drs. K.L. Narsimhan, and B.M. Arora or listening to big original ideas from Prof. Rama and others in Physics Colloquium stimulated our minds.

... and the lively and enjoyable environment created by our fellow graduate students. Bajji's film club, Rangarajan's Bridge tournaments and the Cooking nook of Arun Grover took the boredom out of our lives. Playing Carrom with Bansal, Navalgund & Dinesh was full of laughter, jokes and fun. Playing chess with late Karamjit Arya was challenging, but always enjoyable. We would work well past midnight in our labs and then walk to Hotel President for a snack. On our way back sometimes we were questioned by one of the patrolling Navy jeeps. But they were kind too and gave us a ride back to the Hostel.

Overall, I think it was a mix of our carefree youth, intellectual stimulation setup of TIFR and the urban cosmopolitan environment of Bombay that made for this unique TIFR experience. It is hard to duplicate elsewhere.

### **Narendra Singh (GS 1975)**

*Emeritus Professor, Auburn University, USA*

I joined the Molecular Biology Graduate Program at Tata Institute of Fundamental Research in January of 1975. Unlike all my peers in the department, I came from a Plant Sciences background, but I was eager to learn. I thought I had prepared myself well to transition to the exciting and growing field of molecular biology, but I had much to learn. Luckily, my mentor, the late Professor Obaid Siddiqui, was patient. He provided guidance and encouragement as I made my way in the discipline. My peers and the technical staff were happy to share their time and knowledge. With the department's overall excellence and guidance, I gained the ability to pursue my research independently and proficiently.

The Molecular Biology Unit was a small part of the overall Physics faculty. Our group was vibrant, visible and functioned as a close-knit family. We understood each other's projects even though we worked on diverse model systems with their own unique basic questions. Although research was very important, greater emphasis was on development of scientific curiosity and critical thinking.

I completed my dissertation at the end of 1978 and returned to my teaching position at Ranchi University. Those four years at TIFR were a wonderful part of my scientific life and prepared me personally and professionally to develop my scientific and academic career. The unique life changing "TIFR Experience" is etched in my memory. There are many of us in the TIFR diaspora in North America. We brought the best of India with us and know that TIFR will continue to be a powerhouse of excellence.

### **B. Subba Rao (GS 1970)**

*Professor, University of Kentucky Medical Centre*

I was a graduate student in the Molecular Biology Unit (Dept of Life Sciences) under the mentorship of Prof. U. W. Kenkare. This experience gave me an incredible foundation for my research career. Indeed, I have worked in many places throughout my career, but I have never witnessed as intellectually stimulating and challenging atmosphere as at TIFR. I met many bright minds, made many friends, and am lucky to say that I have maintained many of these friendships even now after almost 50 years!

Although I trained in molecular biology, I became an immunologist. Two of my major contributions are showing the importance of B-cell receptor signaling for malignant B cells and the importance of defects in macrophage function for immune responses to polysaccharide vaccines in neonates and the aged. I am indeed grateful to all the professors and the support staff at TIFR for creating an outstanding environment for scientific endeavors, creative thinking, and a very friendly social atmosphere.

### **K. VijayRaghavan (GS 1978)**

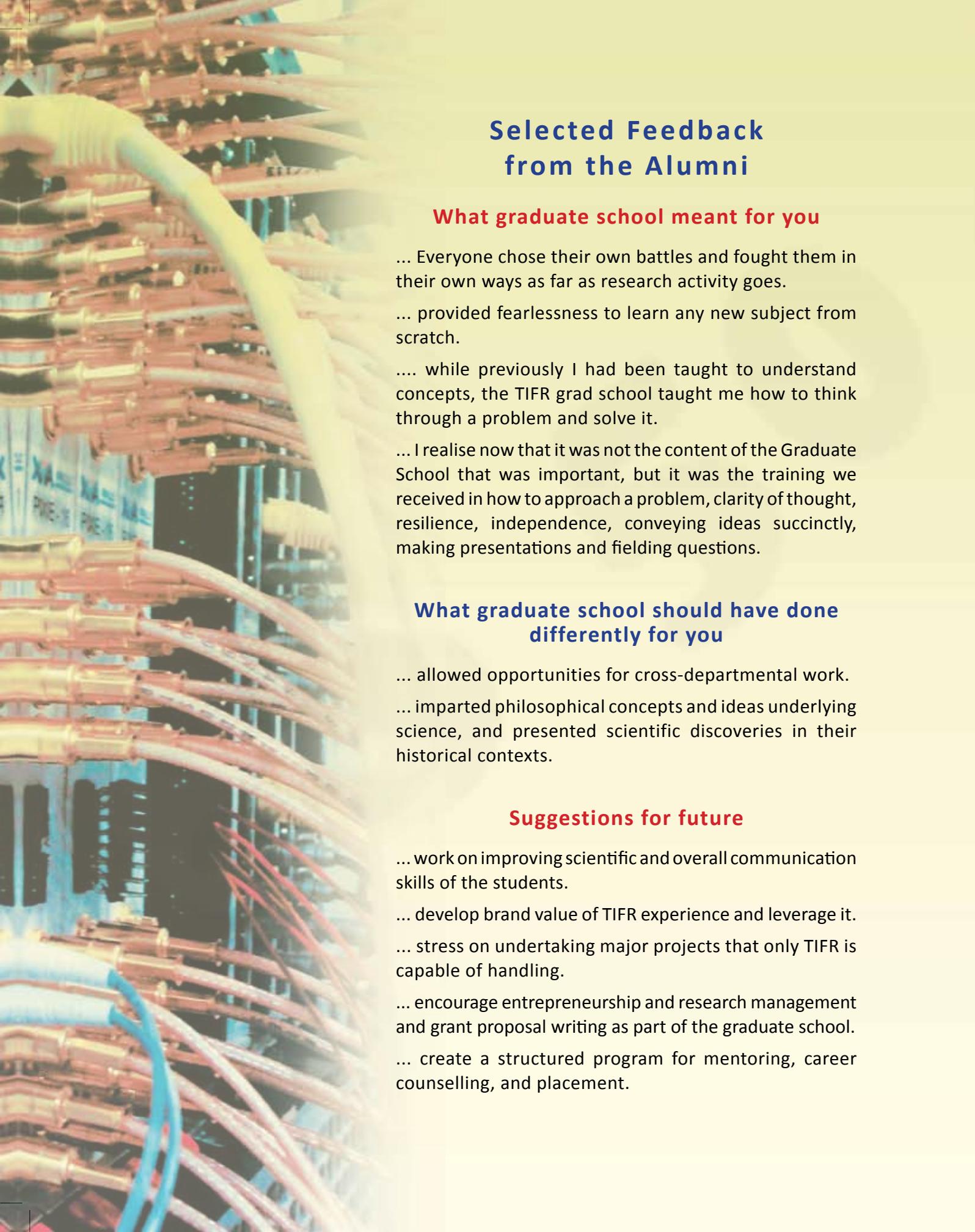
*Principle Scientific Advisor to the Govt of India; Former Centre Director, NCBS*

In 1977, I had a 'gap-year'. I had finished my M. Tech in chemical engineering and was to go to Zurich for my Ph.D. But, I fell ill and after recovering joined the biochemistry department at AIIMS Delhi as a Senior Research Fellow in Professor G.P. Talwar's group. In the biochemistry department library I came across an article by Obaid Siddiqi on fruitily neurogenetics in the conference proceedings of a human reproduction meeting; Talwar liked to get 'lateral' thoughts into his meetings. Stimulated by this article, I wrote to Obaid asking if I could join his lab. My letter was gibberish and undecipherable and therefore open to more generous interpretations than it deserved. Obaid passed it to K.S. Krishnan, who could decipher anything generously, and who asked me to come for the Ph.D. interviews. The interview committees had physicists and biologists. The biologists thought I knew physics and the physicists thought I was good enough for biology.

The graduate programme was paradise as there was no programme whatsoever. I chose to work in P. Babu's lab, register for my Ph.D. with Obaid as my guide and worked on a problem, muscle development, that neither worked on. There was no coursework. Obaid organised a 'course' of lectures on neurogenetics where we each student gave a lecture. After a disastrous lecture by another student he said that every lecture should be well prepared. We must assume that our audience knew nothing but, if presented well, could understand anything, Mine was on *Phycomyces*, the organism Max Delbruck was working on to understand 'neurogenetics'. I never prepared harder in my life and can still remember the Delbruck lab papers. Obaid also got the best neurobiologists in the world to give a lecture and lab course in 1980 at the National Institute of Oceanography in Goa. And, there were the Mahabaleshwar courses each year. None of these were compulsory. There were no grades and there was no comprehensive exam. We were thrown into the deep-end of the pool but all of us learnt to swim.

In today's GS, that flexibility seems to be lost. Why should I, as a student, now be confined to a departmental structure ? Or a biology or physics board structure ? Could I not do a course in astronomy and biology without recourse to a formal nod ? Could we not, after joining biology, move to a programme in theory physics and steadily meet the requirements rather than be tested at entry for one subject ? ...

Today, as we celebrate our past, it is important to visualise our future. Today's world is very different from that of 50 years ago. We have an opportunity, particularly with the impending growth of the Hyderabad campus to envision a new, and even more vibrant graduate programme than the excellent one we surely have, which is the best in the world and helps point our students to new adventures.



## Selected Feedback from the Alumni

### What graduate school meant for you

... Everyone chose their own battles and fought them in their own ways as far as research activity goes.

... provided fearlessness to learn any new subject from scratch.

... while previously I had been taught to understand concepts, the TIFR grad school taught me how to think through a problem and solve it.

... I realise now that it was not the content of the Graduate School that was important, but it was the training we received in how to approach a problem, clarity of thought, resilience, independence, conveying ideas succinctly, making presentations and fielding questions.

### What graduate school should have done differently for you

... allowed opportunities for cross-departmental work.

... imparted philosophical concepts and ideas underlying science, and presented scientific discoveries in their historical contexts.

### Suggestions for future

... work on improving scientific and overall communication skills of the students.

... develop brand value of TIFR experience and leverage it.

... stress on undertaking major projects that only TIFR is capable of handling.

... encourage entrepreneurship and research management and grant proposal writing as part of the graduate school.

... create a structured program for mentoring, career counselling, and placement.