Vignettes for Success in Academia

A Guide for Young Researchers

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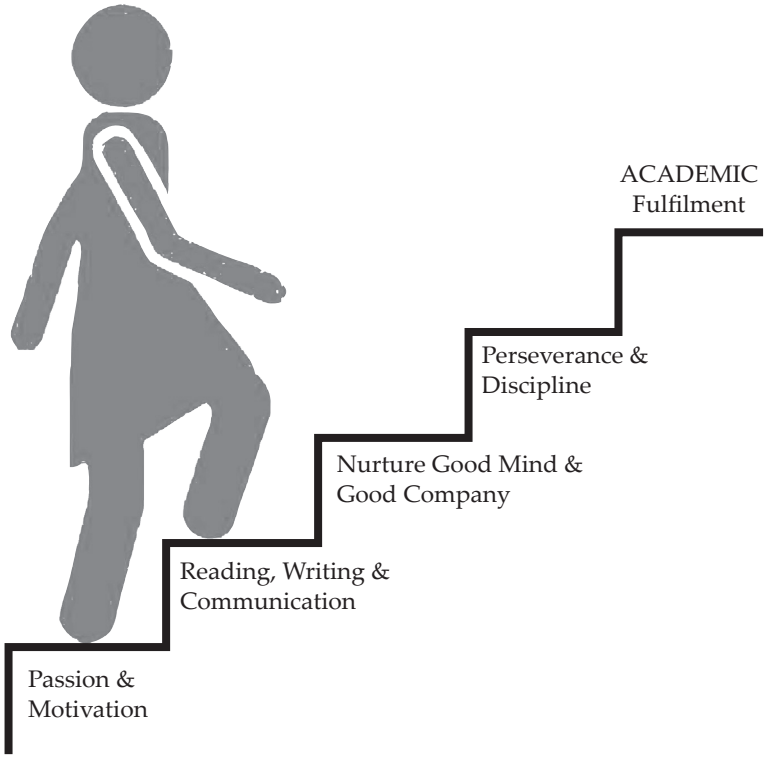
Dedicated to

The students

of the

Bagchi Group -- Past and Present,

with author's love and blessings



The articles in this book were written from an ardent desire to provide a helping hand to young Indian students and researchers who face an uphill battle, often with limited help from the system. Biman Bagchi, as an educationist and a teacher, recognized some of the limitaions of our education system and discussed them openly. As Prof. Bagchi has himeself been a researcher now for more than forty years, he could also offer certain suggestions that are expected to help budding scientists navigate better in her/his lonely travel across the academic world.

Foreward

The firmament of Education and Research in India requires a deep introspection in its teaching methodologies for preparing students towards an effective career in research. In general, students entering a career is research in India are grossly unaware of the rigors, tribulations, ecstasies and of a passionate commitment needed for a research profession. Therefore, Indian research scholars, invariably face difficulties in charting out a successful trajectory in research as a career option.

With a few exceptions beside professional teaching, education in India does not provide students the professional skills cardinal to a worthwhile and a sustained career in research. There is also a general absence of mentorship in these important dimensions of research as an occupation. Consequently, compared to their western counterparts, the Indian research scholars begin with a distinctive disadvantage. And, often their limitations continue even at the faculty level, leading to a compromised performance in the long term and a lack of training to their students.

This book, distills the personal experiences and wisdom of Prof Biman Bagchi, with a five decade long illustrious career, both as an eminent researcher and an acclaimed teacher in the areas of Physics, Chemistry and Biology. This book is based on Prof. Bagchi's experiences with students in India and overseas and appraises them of the minimal needs for a sustained career in research, besides of course, the professional acumen. He thus discusses aspects of self-learning, self-appraisal, failures and successes, creative and critical thinking, and the importance of effective

communication in both written and spoken domains. He also provides many practical suggestions, including those needed for a successful search for a position. The discussion is buttressed with numerous well-narrated examples and quotations from acclaimed scientists. The author fervently hopes that the book will, help, inspire and guide the young researchers in enhancing their, vision and self-confidence.

Over the recent years, INSA has assumed the responsibility of mentorship of younger minds and has initiated many programs, including publishing such books. This book, the second in this effort, is a part of the INSA- DST- Science and Engineering Research Board initiative on mentorship.

I have personally enjoyed reading this book and compliment Prof. Bagchi for this eminently useful and timely contribution. I also thank Prof. A K. Singhvi for the review, editing and coordination of this book.

Prof. CHANDIRMA SHAHA
President INSA

Preface

The motivation to write the chapters contained in this book comes from a perceived necessity to provide a helping hand to students and young researchers pursuing studies in higher academics. I noticed that there are a large number of excellent and motivated students who could be in danger of losing out in the absence of a "guiding light". The students are often clueless and ignorant about the practicality of an academic life, about the pragmatism that is essential to excel and succeed in this difficult and highly competitive profession. The difficulties faced by the students often arise from a partial lack of understanding of the "bare necessities" required to attain certain degree of academic success and/or fulfilment. For example, the importance of writing, and continuous reading, are forgotten by students once they join a research laboratory, especially in India. As papers are often written with the help of the adviser, a student never really learns to write good and meaningful sentences. This alone ruins the prospect of many students whose population I would put at about 30%.

Thus, the articles are partly advisory, partly informative, partly motivating and often critical. In fact, more often than not, I have tried to directly address the real issues as I have seen them. In the process of writing these articles, and from the responses and comments received from students and young researchers, there is a real need of such articles to engage students in discussions on such topics as student-adviser relation, selection of right problems, selection of right thesis guide, importance of communication and the need to develop a good writing skill, and so on.

As these articles are written for students, I shall be happy and myself consider successful if they can reach and help students and researchers. That is the sole purpose of bringing out this book.

Prof. B. Bagchi

Acknowledgement

First and foremost, I would like to acknowledge the students of my department, Solid State and Structural Chemistry (SSCU) and of our own group, for providing much of the motivation for the articles contained in this book. Among my colleagues, Professor T.N. Guru Row and Professor S. Natarajan have read and offered comments and criticisms. The articles were diligently corrected by Dr. (Mrs.) Sarmistha Sarkar, and also by several students of the group. But overall, Sarmistha coordinated the collection and organization of the articles. Mr. Saumyak Mukherjee and Mr. Sayantan Mondal deserve special mention for the arrangement and beautification of the book. I am thankful to all who have helped on the way.

I received a large number of comments on these articles. Many PhD students around the world repeatedly told me that they find these articles motivating and that there is a real need, especially for Indian students, of such a book that directly addressed their concerns and their issues. Probably these responses and comments motivated me to write many of the articles.

I found that writing these articles is a wonderful way to express myself, and also a vehicle to think critically about issues. The opinion expressed here are solely those of mine, so are the mistakes. Although critical (sometimes), the idea is never to hurt anybody.

It gives me great pleasure to thank Professor Ashok Kumar Singhvi, Vice President (2018-2020), Indian National Science Academy, New Delhi, for painstakingly going over my

writing and editing/correcting/improving where ever was necessary, although whatever mistakes left are my sole responsibility. I am truly grateful to Professor Singhvi for all his efforts to bring this book for students into fruition.

Prof. B. Bagchi

Contents

"We rob the child of his earth to teach him geography;
Of language, to teach him grammar;
His hunger is for the epic; (but)
He is supplied with chronicles of facts and dates."

– Rabindranath Tagore

"Education is not the learning of facts,
But the training of the mind to think."

– Albert Einstein

1

How to transform yourself into a hard working student
(that you must become)

I wrote this piece as our present PhD students (even post doctoral fellows) often seem to be at a loss. They come and go but do not achieve much. I suspect they need some guidance. This is the first of a few pieces that I wrote to help them.

Transform yourself into a hard worker – you can do it at any stage. Here are some steps. They are not easy but not too difficult either. The most difficult effort of course, is to form good habits. But this is how it can be done.

Rule #1: *Stay with another hard worker*

Befriend a hard-working person. Remember that time is really short. Try to be with other hard woring colleagues and not with easy goers or lazy persons. I have seen many students transformed when they pair up with an honest hard-working student. So, it is best to avoid lazy friends. How does one spot not-a-hard worker or a lazy person? Simple; such people talk a lot, take frequent breaks for coffee or snacks, criticize others, and are unusually vocal. A hard worker keeps a low profile (in India, at least). Lazy persons also have a charm with an easy going attitude and nice smart talks. Beware from being exploited by them.

Rule No #2: *Discipline and adherence to a routine are critical for a career in Science*

Time management and focus on Science is critical and

over indulgence in extraneous activities such as TV, Internet, WhatsApp and every other mass media are to be avoided. Their use should only be limited to professional needs. Ensure that the schedule once sent does not get compromised any time, except of course on the rarest of rare occasions. Self-discipline has to be the life style, and is to be followed 24x7, i.e. one should be working even on weekends. Do different things during free time but follow a similar routine. This practice is followed by all hard and successful workers known to the author.

Associated with discipline is to have faith even when nothing seems to work. Remember the three P's needed for success: *Passion*, *Practice*, and *Patience.* The last P being the most difficult one to realize, but it always works out in the long run, so long as one is doggedly perseverant.

Rule #3: ***Be a bit of a writer. Write something every day***

This is an essential attribute for PhD students. Writing helps in crystallizing ones thoughts and is a way to discipline oneself. It is in a sense like meditation, if done at certain predetermined times. Writing really helps discipline ones mind and clear his concepts.

Rule #4: ***Do not be a quitter but look for alternative solutions, particularly if you are not interested in a given experiment or a project***

One needs to detect early if a project or experiment is not working as it will be increasingly frustrating and discouraging to persist with a project that does not seem to lead to any logical result. In the authors PhD Thesis work, after a year of effort, it was realized that a problem would not work. But his adviser however was not willing to heed to his arguments and the desire to leave the problem. To ensure that precious time is not lost, he teamed up with

a colleague and worked on alternative problems. Despite disagreement, the results that were obtained eventually constituted 75% of the thesis and was appreciated in the thesis defence which was, truly rigorous those days.

Rule #5: *Do not keep quiet when you have a difficulty*

Discuss thoroughly especially before you are going to implement Rule # 4. Learn to express yourself clearly, firmly but politely. Always write down the points for discussion. Discuss your problems with well meaning and serious colleagues whom you can trust for their wisdom and genuineness. Avoid idle students who are quick to give easy solutions. Unfortunately, we are ultimately all alone in this world. You need to reach out, discuss, and feel the world.

Rule #6: *Be Aware of your successes. Do not belittle them*

Enjoy your success and reward yourself when you accomplish something concrete through hard work and perseverance. Accomplishment can be just in putting in a good hard day's work. In the past, the author's own reward used to be a big ice cream or even a good dinner in a restaurent. That said, actually rewarding oneself is easy-it is the accomplishment that itself is a reward. But try to keep the good feeling when you have indeed accomplished something. You have a right to feel happy and proud even with small successes.

Unfortunately, in India, people try to pull you down making it difficulut to share the news of success. The author can recall that once when after working whole night, he succeeded in deriving an equation and was happily leaving his office at 7:30 AM, he encountered a colleague who asked "Why do you seem to be happy this morning?" His reply was that he had just derived an expression for wave

number and frequency dependent dielectric function. The reaction was, "So, would you get a Nobel Prize"? It was so sarcastic that it really hurt deeply. That is a lesson in this stage. It is necessary to cultivate, having good friends to share your successes and joys. Accumulation of small things matter. Even writing a small code that works well, is an achievement.

Rule #7: ***Be loyal and be respectful***

It may seem odd but it helps to be loyal and respectful to everything around you. If you are loyal, gracious and grateful, you will get good people around you. If you are loyal to your instrument and handle them carefully, they will work well when you need it. And, if you are loyal to your laboratory environment, it will help you do cleaner experiments. The list is long.

Rule #8: ***Be honest and trust worthy (even when your colleagues/seniors are not)***

Hard working people are always honest (well, a few exceptions "worst are full of passionate intensity"). Honesty and hard work go hand-in-hand. Among all the people I have seen, the Japanese are the hardest working, amazingly honest, highly disciplined and the most modest.

2

How to survive your PhD years (and your thesis adviser) and still earn a living afterwards

In India (and probably elsewhere too), PhD students survive largely through solidarity among themselves and with advice from seniors. Though the number of scholarships have increased, job opportunities have not, thereby creating an imbalance with a large number of PhD students getting stranded after their degrees. Ironically a significant number do not have permanent job even after a post-doctoral tenure abroad. While this is probably a part of a larger problem that cannot be discussed here, the seniors and supervisors do need to tell students frankly of what they are up against and how to go about surviving in this fiercely competitive and at times unjust world – a jungle.

The best advice my Thesis adviser Julian Gibbs gave me after my thesis defence is "Biman, there is a jungle out there for you now". Another professor joined in, "You were protected so far, but now you are on your own. It is a real jungle".

Some decades ago, academic life used to have a charm and was an attractive career option, at least in some pockets of India. I remember a book named "Gentlemen under the elms", which was a description of Professors in the Ivy League Colleges. Those days I did not know what an Ivy League was. But the description of umbrella carrying Professors, with looks of a philosopher suited well with many Professors I knew in my locality. And, there were many as we

had two large colleges nearby. These Professors/ Teachers were hugely respected and were invariably the presidents of *puja* committees.

In recent years, the academic ecosystem has degraded and for obvious reasons. In those old days, there were only a few students and also a few jobs. Thus, many PhDs used to get absorbed in their alma mater. From the kind of professors and the rigorous training they imparted, everybody must have gotten jobs those days. Things improved a bit for a while in the 1970s and 80s as many new Institutions and Universities were opened as the country started to develop in the post-independence era. We witnessed another growth in the initial years of the new millennium, but things have slowed down almost to a near standstill now.

A student entering a PhD programme often does not realize and far less understand that he or she is taking a big chance with his/her future. It is almost a gamble. To begin with, no student thinks of failing in the endeavour - by failing it does not mean the degree which is mostly assured, but it is with what follows a degree. If the latter (that is, not finding a suitable job) indeed happens (God forbid) then it comes at a stage and age in life when not much can be done.

What makes the situation worse, particularly in India, is that the support/advice from the system (i.e. adviser, department, institute or society) may be inadequate. And, such instances are commonplace - not only in India but also in other countries. This often leaves students very frustrated. In addition, left with an *"amputated spirit"* for which often *"there is no prosthetics"*, the career of the student (who is often close to 30 years) is in a complete jeopardy. One knows of numerous students who are just sitting at home after finishing PhD, or sometimes even before finishing PhD, as things did not go well.

With so much at stake, there should be a lot more of discussions about a student's future and career path but

this rarely takes place. Both the system and the students are to blame for this strange lack of initiative to protect a young mind from, what is often an impending disaster. A serious introspection at all levels is called for.

A distinctive problem in the academic world is that, kindness is NOT the biggest virtue. Here competition is so tough that it is sometimes hard to believe that hundreds apply for a single job.

There no easy solution for a problem of this magnitude, but the following can be recommended towards avoiding a disaster, akin to the advocacy of Naturopathy for the prevention of disease.

1 For a student, it is important that before entering a research career he carries out a SWOT analysis- some things that industries/managers routinely carry out. SWOT is strengths, weaknesses, opportunities and threats, and the student should self-evaluate her/himself, in respect of the choice of subject, aptitude for research and the future career options. Due diligence in this is a must to avoid disappointments later.

2 In selecting an adviser, given a choice, one must follow his passion. This is a bit unconventional an advice at present times when everybody opts for applied sciences. Following one's own strengths and subject choice will prove far more beneficial in the long run. It is also important for one to keep his spirits up so that, if needed, a mid-course change can be made. It is important that one likes his work and has conviction about his ideas. This will provide more chance and ensure that one succeeds. It is always desirable that one is pragmatic in these matters and is not unduly idealistic. Wider consultation and extensive literature search would always help.

By the 3rd year, one needs to take a serious review of status of his work, his standing and the future prospects. It is

the time that that one takes full charge of his research and starts to look around for opportunities in academia and if possible in the industry. There are now a number of R&D positions in multinational companies that could be good choices. Several Indian PhDs who joined such R&D labs after their foreign post-doctoral stay, made contact with these companies during their post –doctoral tenures. This proactive action is important to ensure a seamless transition and a continuity in career trajectory.

It is important to plan ahead and keep several options at any given time. It must be understood that life shall not to be easy after PhD, after a Post doctoral tenure and then as a teacher or researcher.

A common observation has been that most PhDs and post-doctoral fellows start their search for jobs by looking at IISc and IITs and IISERs. These institutions are now nearly saturated in respect of their faculty needs and also these institutions tend to select candidates with PhD or post-doctoral experience from international institutions. Recent appointments in the Chemistry departments of IISc have all been PhDs from international institutions.

It is not that foreign PhDs are any better and that is not the only reason for their selection. It is that they often offer easier and an easy to defend option. It will be prudent for a candidate to look also at the state universities, colleges and private educational institutions. Many of them encourage their faculty to do research, although they do not offer much resources. One of our post-doctoral fellow accepted a job in a private engineering college as a Head of the Department, and has been happy. He loves to teach, goes to conferences and has now an acclaimed mentor. The key is that one need not get bogged down by the clichés in job-hunting and should keep an open mind for an optimum choice from the opportunities that are available.

3 It really helps when one develops lots of meaningful professional contacts, mixes with colleagues during conferences, maintains humility and corresponds with professors even when they are not able to reply. They will for sure read the e-mails, but may not find time to answer. Write letters for advise and provide them with complete information (such as CV or the details of the experiment or the job profile) to enable them to respond without having to write back for details. Such life skills of communication are needed for one to grow and this is best done by sharing thoughts and publications on a regular basis. Effective, regular and meaningful communication is an integral part of any successful research career.

4 Post-doctoral tenure is a serious opportunity to build a career trajectory by demonstrating one's independence as a researcher, developing one's own research plans and establishing a broad based network through varied communications. One needs to be concerned, be constantly engaged and not be unduly scared.

Several post-doctoral fellows spend time working abroad, are busy toying with several job ideas, but do not take effective steps to ensure that their plans come to a fruition. Try everything so that when the time to take a call arrives, one has multiple choices. One should begin preparation for this from the day they start their post-doctoral tenure. This will provide sufficient time to prepare for realizing one's dreams. Timing and time management is crucial for a career in Science.

There are examples of a colleague who seriously looked for jobs for 2 years by starting early and at the end he had several offers that permitted him to keep his options open to make an informed decision. That is a correct strategy. For various reasons post-doctoral

fellows in India do face slight disadvantage in respect of academic jobs. Therefore, in fields where possible, jobs in industry should also be explored and pursued.

5 The real key to success is the quality of research, the number of publications, one's clarity and vision for his future trajectory in Science. Communication skills are essential in demonstrating that one is not only good but is obviously good and this will require lots of preparation, which will matter, and matter decisively.

6 With some effort, even Indian bred students and post docs can and have also succeeded. The forgoing will truly apply to those who shall have a certain number of publications and are good workers.

7 Behind the glamour and laughter in conferences, there exists a hidden river of sorrow of unsuccessful students and post-doctoral fellows who quietly disappear and some just stay unemployed at homes. They are quickly forgotten.

8 Surely, as is true elsewhere, kindness is not the most important virtue in academia. Jobs, like those in the IT industry, are no better and equally demanding.

9 It is worth repeating that one should enter academics only after due diligence of weighing his professional competence and willingness to work hard and other attributes of such a career.

3

Creativity and competence: to understand and conquer the twin pillars

This chapter is for graduate students in India. In the present day Indian society (and probably everywhere else) one can perhaps comfortably get by, by acquiring competence only - so creativity is undermined, not to say that this has been the most elusive of all human abilities. Creativity is difficult to define and arduous to achieve. Worse is, of course, when one does not have either of these attributes! Though this chapter is designed for students, others may find something of interest as well.

Thomas Edison famously said, "genius is 99% perspiration and 1% inspiration". This is to an extent antithesis of the common belief about a genius. What distinguishes geniuses from other lesser mortals, i.e. 99.9% of the humanity is their creativity. They seem to be capable of producing a rabbit out of a hat! And, some of them seem to do it so effortlessly that one does not feel envious but is filled with admiration. Where role do the hard work and competence play?

During the author's PhD at Brown University (Rhode Island, USA), students often used to have beer with a young assistant professor in Physics. He used to show up on the weekends after 9 or 10 PM and as other students - had neither a wife nor a girlfriend. But he was interesting, talkative. Once he told me point blank, *"you Indian students*

are good calculators, but not creative". I was too meek to protest, also did not have too much to defend it with. But I remembered this comment from the young assistant professor ever since and with a sense of gratitude. Indians are supposed to be good in theory, so if they are not creative in theoretical studies, the chances of their being more so in other areas is probably equally bleak. But Indian do succeed with competence, as the success story of IT sector demonstrates.

The issue of one culture being more creative than others has been in discussions forever. Long time ago one heard that Japanese people are not creative (those were the days of Xerox machines made in Japan being of better quality). Then it was the turn of Chinese to be labelled as being not creative. And, as mentioned, Indians are also, according to this physics assistant professor, not creative. But maybe there are some kernel of truth in all these, and this is examined below. The word that comes close to "genius" in Sanskrit (and in Bengali) is *prativa* and in Hindi it is Pratibha). *Prativa* means a certain kind of enlightenment, a state of highest learning and exceptional understanding. What both the words have in common is certain and in no small a measure, convey a sense of some thing unreal or uncommon. *Prativa* is probably easier to define while genius can be explained only by examples. And indeed such examples abound.

Discovery of graphene, fullerene, high temperature superconductivity have been three landmark discoveries during the recent decades. A large number of scientists have been working on these currently, but these were discovered by small isolated groups and, the credit goes to these groups for these remarkable inventions. Often, geniuses are not recognized during their lifetimes. This is truer for painters and writers. Franz Kafka, Fyodor Dostoevsky, van Gogh and many others were all celebrated only after their death. Scientists have so far been luckier.

Returning to the issue of competence versus creativity or competence *and* creativity, I have often looked into the difference in the working method (or style) of Indian (or Asian) and American students. The author has been fortunate to work with a large number of students from different countries and continents. I can broadly divide students into two categories — Asian and Western as state the following with a degree of certainity.

The western students are often slower in their approach but are more scrupulous, more systematic, painstaking and more dogged in their approach and are less likely to get stuck. They are more independent. Asian students are often quick in making the initial progress but are liable to getting stuck midway. Their initial flair dissipates when difficulties arise on the way.

Competence means a demonstrated ability to pursue with whatever tools or methods one has and the ability to pick up new tools and approaches, as and when required. This is not scholarship or knowledge, but hard work and perseverance and can be referred to as *evolving competence;* an ability to harness certain previous knowledge diligently, but at the same time, the ability to pick up new techniques when required.

What is often not realized is that geniuses work extra-ordinarily hard. The genius the author worked with, Prof. Robert Zwanzig, told him that when on a problem, he would hardly sleep but would laze around for a month or two after solving it. He constantly learnt new things even at an advanced age with great zeal and enthusiasm. New techniques and results always interested him, of course, only after they met his standard.

A correlation between competence and creativity exists. *Creativity has in part an element of evolving competence* - the never ending quest towards the completion of an endeavour once begun.

One of our great forefathers was Sir Ashutosh Mukherjee, who along with others founded, the Science College of Calcutta University. He was an outstanding mathematician (an FRS at the age of 24!), and observed the following difference between the English and us. He stated (translating to English), "Among the saheb (the English), there is a tendency, like a bulldog, to finish something once started". It is known that a bulldog does not let go the prey after they bite.

A part of the astounding creativity demonstrated by the British, French, German, Italian, and other Europeans during and post Industrial Revolution era could be traced to this insistence at clinching or "killing" a problem. Also, persevering till a certain satisfactory level of advancement is achieved and doing so fearlessly. There are other examples as well such as theory of liquids developed by Andersen, Chandler and Weeks, protein folding by Wolynes, Onuchic and many others. In both cases, the initial work was quite far from the final form, but Chandler, Andersen, Wolynes pursued these for several years before an acceptable form emerged and their persistence and a logical thinking or resolving obstacles on the way, paid off.

This attribute of persistence is absent among Indian students and scientists. The quest for quick results in the modern culture is seemingly omnipresent. If one attributes some of the successes of geniuses to this evolving competence through doggedness, then it is an interesting question as to how much of this attribute is an inherent ability, how much of it can be developed and how much of this comes from being born to a given culture?

Certainly a culture that copies others cannot be creative. People, who copy, lack both the self-respect, dignity and it is an exercise in futility to expect them to be creative. But one can however become competent by copying, as our mobile-based culture amply demonstrates these days.

There lies the difficulty. Thus the very act of acquiring competence (like qualifying for IIT-JEE exam) compromises the creative urge of a student. Here society really plays a huge role, and in India we as a society have failed miserably through over emphasis on competitive exams and marks and the quest for an early success in career and monetary aspects kills the creativity. And, such non creative people when in position can only breed mediocrity.

The central issue is: how does one acquire a high level of competence and still remain creative? There is no magic formula and a caution is warranted for exuberant advices such as , "go, kiss the world", "bring the world to your feet" etc. that adorn Indian bookshops these days. However, a few suggestions are given below.

i) ***Self-analyse*** (know thyself). One should critically and honestly assess one's ability. Competence is partly internal and one can be good at only a few things. For example, with a short frame one cannot be both a good basketball player and an exceptional TT player. One needs to identify, what is he good at and carry out his SWOT analysis.

ii) To be really good at one or two areas of work, you would need to like them to the extent that they become *your hobby.* This may even necessitate a change of thesis problem and research direction and must be undertaken. A discussion with the thesis Adviser is recommended. Several examples exist where students asked for a change in problem and the decision turned out to be a great one. There is absolutely no wisdom in continuing on research trajectory, if it does not resonate with one's aptitude.

iii) To a great extent creativity originates, from knowledge, and from making interlinkages. This requires wide reading not only of ones' own area of research but in

areas around as well. Also discussion with peers and attending in seminars with an open mind towards developing scientific linkages help in scientific career. The authors first three contribution that are now acclaimed came from his studies outside his core thesis problem carried out during free times. They served him wonderfully– although he did not anticipate this when he was learning and reading beyond his research work. Thus, extensive reading open up and prepares one's mind for new avenues and novel linkages. Creativity then is just an extra bit of new knowledge infused in to the work at hand. No wonder, Prof. Bob Zwanzig was ever so eager to pick up new techniques and ideas/ insights.

iv) ***Try to work in an emerging area.*** This makes it simpler for a young student to develop competence in a cutting edge, quickly. A mature area can be frustrating as learning is slow. It is far easier to know many things in an emerging developing area. One can then diversify to different areas later.

v) Creativity is *evolving competence*. As Prof. Zwanzig recommended that a serious student must learn as many new concepts and new techniques as possible**.**

vi) Linus Pauling said that *to have one great idea, one needs to have many ideas* (paraphrased*). This calls for a continued quest for ideas in the areas of work and around it.* This is where the idea of evolving competence enters. One needs to develop the ability to pick-up new techniques and for this the ecosystem should also be supportive i.e. the support of people and facilities, which are lacking in India. The country is full of many big talkers (and the takers of such talks) but only a few endeavour to help others including young people. We have evolved into a self-seeking inward looking society obsessed with a zero sum game, rather than being an enabling society.

vii) *Be aggressive with a new idea* and pursue it passionately. That is, recognize the novelty, even if small in degree, and then devote as much time as possible to quickly evaluate and realize the new idea.

Once again, a golden dictum will be that a student keen on a career in science, must continue to learn, explore current ideas and modern techniques.

4

Is the present academic set-up helping our PhD Students and post-Doctoral Fellows? (or is it leading them to "academic and financial exile")?

This is a continuation of my concerns about PhD students who sometimes seem to be at the receiving end of an indifferent and cruel system that serves to benefit a few at the cost of many. However, I have no immediate solution but do try to provide some guidelines. But I think even a healthy and democratic discussion of the issues raised will be useful.

The title poses a question and derives from a statement made by a young Indian Post-Doctoral fellow whom the author met recently. During the ensuing discussion the statement contained in the title was made. His friends degree travelling with him mostly agreed. In their mind, a PhD has become just all pain and no gain effort. It was also felt that students are used to advance career trajectories of faculty members. These sentiments almost represent their views verbatim. The reasons of such a negative statement from a group of young post doctoral student undoubtedly need a serious discussion. There are just two reasons. First, thesis advisers use students as "use and throw" material, with little regard for their training and development. Second, the job prospect after PhD or post-doctoral stints are limited and nobody at any level is bothered. Both are eminently valid observations.

With a personal knowledge of a large number of students who are stranded and desperate for job after a post-doctoral tenure, the resentment and the anger of these students is totally justified. To be quantitative, the author personally knows about 20 Indian students working as post-doctoral fellows abroad, those who are keen to come back and have no avenues to do so. This is a very scary situation. At one time it was stated that "whoever has quality gets a job. This certainly not true anymore, as the jobs are decided on factors other than merit. Also the world is producing far more PhDs than it can absorb. There is no exception including India.

The main question is then should we continue to admit so many students and give them apparently useless degree that guarantees unemployment? If these students after half a decade do not get jobs or livelihood, then it certainly is a scam. As of now and certainly the entire post-doctoral program seems to serve only the professors and the establishments. Professors seem happy going around the country and the world.

It is ironic. We give the students a fairly good fellowship, then offer them a good Post-doctoral Fellowships. We make their life somewhat comfortable for a while, but then leave them high and dry.

Exceptional individuals like Professor C.N.R. Rao built many institutions and departments and these created many jobs, but such efforts are few. And, his is an exceptional example and success story, although seems difficult to emulate as most of the Institution builders have been business magnets like Tata, Birla, Rockfeller. The time is ripe to carry the torch from Prof. Rao and build more institutions. Of course, this is easier said than done, but we need to say it often for it to rub on minds, that matter. It is appropriate to recall the saying, "Watch your thoughts, they

become your words. Watch your words, they become your action, Watch your actions, they become your character". In this case, it is the authors fervent hope that his words lead to some good action.

One organization that really tries to help its members finding a job is the American Chemical Society (ACS) and the author admires ACS in this regard. They have been helping students for the past five decades, by continuously bringing academics and industry together.

It is true that there should be jobs available in the first place. Then there should be a systematic approach to help the students apply and get these jobs. And, this would work effectively only when the entire process of recruitment is carried out honestly and transparently.

ACS allows networking between students and prospective job hunters. Nothing like this exists in India as yet. Nevertheless, it could be and should be done. In the absence of many industry jobs, can there be a systematic approach for e.g. chemistry or physics or mathematics students having campus placement similar to that for engineering students.

For students with training in theoretical sciences, there could be research jobs in pharmaceutical and, energy research as also in software development. We need to face that number of jobs in academics where one can do both teaching and research is limited. Of course it is also true that young people are mostly content to get a job in a good place, and then their interest wanders and dissipates to more mundane activities. Research should always be for a passionate few and those entering it must be very careful about their aptitude for research.

In addition, there should be jobs in junior colleges and state universities, and also many private universities (like the Amity, Ashoka Universities and many others) that have

now started. For sometime it seems that the flow of money and resources are now reaching small colleges and private institutions.

There is certainly a good potential in that area. In developed countries, numerous PhDs take up jobs in undergraduate and community colleges. There can be a satisfying profession in a life of teaching and some research. Thus, many would not mind teaching at a place like Pomona College or Swarthmore. Such a career option may, actually be a lot of fun. But in the Indian context, our students face politics everywhere.

It is important to realize that everybody need not be and does not even want to pursue higher research, but everyone aspires for an honest profession that would allow them to live a life with dignity.

5

What happens to you when you have been a teacher for too long?

The effort and sacrifice made by sincere teachers often go unnoticed. This is reflected in some rather cruel jokes about teachers. My original intent was to make this chapter funny but after writing it, I realized that it has a bit of sadness. However, the purpose remains fairly clear.

Every Indian teacher knows (or, should know) the saying, if you have been a teacher for twelve years, you have become a donkey. Similar sayings in other countries must also exist. My father who was a teacher himself and was often reminded by others of this saying, mostly in a jocular vein, but not so always. However, even then he agreed to this adage that was probably first stated by Adi Guru Sankaracharyya. To me it implies that a good and conscientious teacher should have been better off elsewhere and if not, he was, a stupid. As I feel increasingly so these days, that I have been a good teacher for long years, but this fact hardly gives any cause for celebration.

So, it is probably worth investigating why teachers become what they are said to become. A related question: do all teachers become so? Or, some escape? Or, does this phenomenon occur exclusively in India? These are "deep" questions; it is worth spending some time on these in the context of another saying that teaching is the noblest profession. Total contradiction!

The low salary (remained surprisingly low for long time and even now it is low for teachers in private schools and colleges), brings a lack of respect in the society. We cannot allow this to happen ad-infinitum. A teacher today gets scant respect in society. It was not so at least in the post independent Bengal. These days the author finds school teachers are often valued by the additional money they make through teaching in private coaching centres. In addition, it has become difficult to get good teachers in schools. Again, it was not so in the author's time. This is sad. However, the reason is not hard to find. One of our best teachers in our school was Mr. Shyamal Bose, our Shyamal babu. I heard that he recently died as a very poor man. His small pension was not enough, and he never wanted to teach at any private coaching centres.

Then there is one more reason for even good teachers become mediocre with time. A simple interpretation is that when one teaches the same things over and over again the thinking power decreases, and by twelve years it disappears. This seems to be a common wisdom.

The other possible scenario is that when one tries to explain things to students again and again, without much success, one has to descend to lower and lower level, at times much to one's consternation. This exercise certainly increases one's patience but makes teaching an experience devoid of challenges posed by good questions.

It is said that to be a good physical chemist, one needs the genius of Emil Fischer and the patience of an ass! And, this analogy has been around in some form or other. In a positive sense actually "patience" is the more difficult attribute to three "P"s we need for success in science and this is the interpretation favoured by the author and accords with his personal experiences.

Now which are the people who escape? First, one has to be a pretty bad teacher to begin with and not in love with the profession. Also, one should start with an immense reservoir of impatience, so that no amount of teaching can make that person a patient human being. Support for this suggestion accrues from well known examples. Both Landau and Pauli were famous for their impatience. Einstein, in his early years, was quite impatient. Based on personal experiences, one hardly sees a creative guy to be patient. Prof. Bob Zwanzig was known for his impatience.

In India, unfortunately not much has been written about the teaching aspects of greats like Sir J.C. Bose or Sir C.V. Raman or others. Sometimes good scientists use sarcasm as a weapon to convey contempt towards a wrong answer by students or to awaken certain shame in students to force them to make more effort, but with time, this could become a habit. At times even wild behaviour of a teacher/professor directed at students is seen. The author would empathize with the frustration of teacher. When a teacher is deeply involved in teaching, inattentiveness can be disturbing. However, students may support the case/cause of fellow students, and this compromises the reputation of the teacher.

Teaching in India could be a demanding and a depressing profession. I remember vividly that some days my father used to return home tired. Even though he was a Principal of the school, he used to teach, mostly English, sometimes Economics, Geography or History, often in intermediate level classes that he considered most important. I once asked him why he was so tired. He used to tell that he took four lectures that particular day. So, even a seasoned teacher like him used to come home very tired. He was an outstanding teacher. Yet he himself used to mention the saying of Adi Guru Sankaracharyya.

Surprisingly we have little writing or discussion about classroom behaviour of teachers. Even students hardly discuss them. Maybe they do and it is not known to others. The book Malgudi Days by R.K. Narayan has some interesting episodes, but in this book, almost everywhere the teacher has been depicted in negative humour. No lesser man than Rabindranath also constantly made fun of teachers.

When at Brown University, the author came across a book (displayed in window of the Brown book-store) entitled "Gentlemen under the Elms". This contained life stories of eleven well-known teachers of Brown, told with respect and tenderness bordering on affection. These Professors seemed to have maintained a standard of teaching throughout their life influencing several generations of students at Brown.

This reminded the author of his own Mathematics teacher at Brown, Prof. Lawrence Sirovich, now at Rockefeller University, NY and still active. He taught Applied Mathematics (course numbers AM133 and AM134). He was a wonderful teacher and we learnt a lot from him that helped in various ways in our research for years to come. Prof. Sirovich was already famous, yet he was kind, very polite and nice. He liked teaching. In his biography, the author wrote a few lines about the immense contribution of Prof. Sirovich to his scientific career. After a gap og 40 years he wroe a letter to Prof Sirovich. As the author did expect (note that this was a huge expectation) to get a reply from, but sure enough a nice and kind mail arrived a few days later.

The author quotes a few lines from his mail: "*My congratulations on your very successful career. Your name rings a bell and your picture elicits a faint recollection in my aging brain. I read with pleasure both your "tribute" and your "autobiography"-thanks for the kind remarks. I sense from both*

that we share a pleasure in teaching. It is one of the more fulfilling pursuits of our profession, at least for some of us."

Here is a teacher who writes such kind and encouraging mail to a student whom he hardly remembers after a gap of 40 years. He is a great teacher and does seem to have escaped the donkey-hood. Teaching certainly enlightens teachers and in some way fulfils their inner desire. And, those great teacher-gentlemen under the elms raised the standard of human endeavour and enormously enriched all those whom they taught and touched.

Things have changed. The most notable difference is that the students now are less responsible. They are now spend more time in parties such as the comprehensive exams parties, thesis submission parties and thesis defence parties, probably many more. Then there are of course distractions due to internet, mobile, facebook and others to take care of the rest of their time. Students in India increasingly live in an imaginary or illusory world and unfortunately, they discover the reality of the demands of a research career a bit too late, when nothing can be done.

Such attitudes, have also markedly changed teachers' ability to connect with students. There must still be outstanding teachers who can do so despite all these. Hats off to these rare persona!

Needless to say that some of these good teachers are extremely valuable, doing more important job for the society than many corporate executives whose face, name and salary we hear every day. In India, we are constantly reminded of these people (who made tons of money!), like nowhere else. Teachers, on the other hand are like magicians who unleash hidden talent and potential in the students and do that untiringly, year after year and thereby immensely benefiting scores of students, and ultimately the society.

But certainly the so-called noblest profession in human civilization never got its due credit, especially in India, where, some one remarked) to my mother about marriage prospects of her own daughter "we do have a nice boy we like, but what can we do? He is just a teacher! Who will marry his daughter to a teacher? How can we consider him seriously?"

My poor mother! Not only her husband was a teacher, her elder son was also a teacher and he was getting married. Fortunately, the would-be wife/daughter-in-law was ignorant about the unsuitability of her future teacher-husband. And, later even his younger son became a teacher! And, she was proud of us all and, in the end, that was all that mattered.

6

Indian or a foreign PhD: what should be the choice? The pros and cons

This write up is a result of many discussions and conversations I had of late with Indian students, but addresses some of the key issues that engage the minds of an Indian PhD student.

With the growth in Indian science (in numbers and in average quality) in recent years, the question posed in the title has a relevance.

There is also the need, of a comparison between merits/demerits of PhD in the USA or Europe as compared to a degree from in India. Students in India deserve frank appraisals of various issues from knowledgeable quarters. And, hence this chapter.

First, students should note that ground reality in the USA has changed a lot in the last few decades. During the late 1970s or early 1980s, research was less targeted and the research environment was free and joyful. I remember that while my great and famous adviser Julian H Gibbs's grant was on water, I happily worked on everything but water. I worked on polymers, Bose-Einstein condensation, Mayer's theory, sol-gel transition etc. Even when I went to Chicago, I went on doing on problems of my choice, and with the permission and support from my wonderful boss David W Oxtoby.

Contrastingly now, one finds even an established and powerful professor frankly telling his student that he needs to work on the subjects related to, and preferably as outlined in the grant proposal.

The reason for stating this is clear. When a student joins a professor, he may have the ardent desire to work on a specific project the professor is/has been famous for, but he may very well find that the desired professor is reluctant to work on the project of student's choice.

In Europe things are more transparent. Students know beforehand what will be their project, and even the duration of the project.

Here are the *negative aspects* of doing PhD in the USA:

One has to do a teaching assistantship (TA) at least for two years and at times for longer durations. It depends on the Thesis Adviser's grant conditions. Of late, even 5th year students have to take up TA to support themselves. This was unthinkable previously. Many supervisors including the established one have difficulty with grants, unless they do targeted research. This is really not what a student has in mind when joining a department for PhD degree and to spend 40-50% of his time in teaching (often demanding) undergraduates.

1. Increasingly lesser freedom in the choice of a research topic. Often the thesis adviser also may not be the ones you went for.
2. Courses are good but now comparable courses are offered at many institutions in India.
3. One has to live away from his family for a long time. This may at times be compensated by friends.

A personal feeling is that the quality of science in some Indian institutions is comparable but overall, the general level is higher in the US.

The positive aspects are:

1. One gets to live in a new country which could be adventurous.
2. If one wants to stay back and can do so, he might have a better life. In the present circumstances this can not guaranteed. And, life is demanding everywhere.
3. One has the opportunity to be in touch with many great scientists although most of them are probably over 50 years of age (if not retired). But still many brilliant minds are still around and available for discussions.
4. Much better infrastructure for research and the work environment is intense with lots of postivity.
5. One learns the norms of collaborative research which has been the strongest point of research in the USA.

In Europe the *negative aspects* are:

1. No well-defined course structure; weaker than at some places in India.
2. Limited duration, lesser rigor.

Positive aspects at Europe:

1. Closer to home, hassle-free and one has no teaching committments.
2. Better living, good food and more places to see.
3. Better infrastructure, easy access to a large number of working scientists.

I did not discuss the money part which I find that not much advantage abroad any more, given all aspects.

An important positive aspect of working in both Europe and the USA is that the scientific firmement is less political. Things work in a fairly transparent manner way and people are more relaxed and frank, with due and objective appreciation of quality. Often more scientific discussions and group meetings take place.

Science has proven that the saying, East is east, and west is west, and the twain shall never meet, is not correct. In science, East and West are converging and to a great benefit of humanity and excitement. And, the geography of science is slowly shifting to the East.

The perspective and view expressed above are personal. The author is of the view is that (to those above 20 or so): One can never become an American in this life. One will remain an Indian – that is if you want to be happy and search for happiness then that, has to be in your own country eventually.

The above is based on a statement from great poet Pablo Neruda- I just paraphrased it. The above was actually one of the last sentences he wrote in his autobiography before death.

Good luck with whatever one chooses to do.

7

Discipline and hard work: chicken and egg problem or is there no correlation?

This chapter explores the latent relationship between discipline and hard work. In research, we often find scientists working hard but seemingly lead a disorganized life style. In reality, however, I found most hard working scientists are quite disciplined, and highly organized as that is the productive way. In fact, discipline itself is hard work.

Let me start with a quote attributed to the Great King Solomon (according to Benjamin Franklin's Autobiography) "Hast thou seen the man diligent in his work? He shall stand before kings; he shall not stand before mean men."

In this context, discipline is to follow certain norms of behavior that helps improve ones professional skills. is usually assumed that a disciplined person is hard working but the reverse need not be true: a hard working person is not always disciplined. There are examples for and against on both sides. Great mathematicians like Gauss, writers like poet Rabindranath were highly disciplined, but on the other hand many scientists worked at odd hours (Michael Faraday) and actually worked themselves to death, with little regard to to an organized life-style. Authors and painters could be extremely hard working but may not lead an organized life style.

But we are not talking about the great ones. Often a mistake that people, especially in India make, is to draw examples

from the rarest of rare people, about whom one can only dream about. Our concern is to deal with ordinary, lesser mortals, like us. I would like to argue for people of average competence (one not putting anybody down as the average here has a lot of span, and includes excellence), discipline, and hard work often run parallel and one actually re-enforces the other. This is important for students to realize who actually waste a lot of time by being indisciplined.

Exceptions are exceptions and several examples of highly disciplined professors who are not hard working, also exists. They come to office at 9 AM in the morning, go to coffee at 10 AM, return at 10:30 AM, again go to coffee at 11:30 AM, lunch at 1 PM - Everything on dot, except they do not engage in any work! Also, there are numerous examples of highly disciplined and highly successful professors.

The forgoing is an attempt to weave a logical correlation, and as must be clear that no discernible pattern can be seen. But bear with me a bit more. In this context, it is enlightening to remember what great philosopher Immanuel Kant wrote on duty in his formidable book "Being and nothingness" (something that I attempted to read in my late teens with only a limited success). Kant said, a duty is something which you perform without any personal pleasure. He gave the example of helping a blind man cross a road. This is not duty because you derive pleasure of helping a blind man. Duty should be regardless, and be performed without deriving personal pleasure.

Interestingly this reminds of the great scripture *Bhagavad Gita*, where we have been advised to carry on with our daily chores, without expecting any reward. It is possible that Imanuel Kant knew of Gita but reading his writing, I tend to believe that he argued it out himself.

What do all these have to do with discipline and hard work? My point is that discipline is itself a pretty hard

work. However, one can not expect anything from just being disciplined. In a certain sense, discipline is, like religion. What religion is to life is what discipline to work. Remember Gandhari's advice to Dhritarashtra in Mahabharata? In Rabindranath Tagore's eternal words *"dharmai dharmer shesh"* that translates to, *religion is an end in itself*, and not a road to any selfish goal.

Since this book is for students, let me try to argue why discipline is good and extremely important for research, particularly in these days.

First, discipline allows one to become systematic. Research requires following a set of safe guards, rules, checks to avoid errors. This is much more important these days than in our times. A disciplined student would scrupulously keeps notes.

Second, a disciplined person is less likely to make a mistake. In these days of research which might involve complex coding or automated measurements, often it is difficult to find an error until it is too late. Then one is doomed.

A disciplined person remains fresh and alert. The world trusts a disciplined person. Once a famous professor told me that he always knew when a student started looking for jobs and going for interviews – he got a nice haircut and a good shave!

One might derive some strange pleasures by working late into night, till 3 or 4 AM, but that makes you more prone to mistakes. You are better off starting at 8 AM fresh. Just avoid going to coffee ten times with friends and colleagues. But remember being disciplined itself is hard work and is a habit to maintain. And discipline need not be confined to one's work. It has to be part of one's life and whatever one does.

8

Professor Paul Barbara
(1953-2010)

I wrote a brief obituary on an outstanding scientist, a dear friend and ex-colleague Paul Barbara in the November of 2010. This was kept on the server of University of Texas, Austin for the last 4-5 years but now has been removed. Many of my colleagues told me to put it in my book. However, since I have lost the original one, this is a new one. It is not easy to write these pieces, but I hope people find them memorable as Paul was a dear friend to many of us.

I had my first interaction with Paul on the stairs of the chemistry department of Brown University in the spring of 1977. I was taking an advanced Statistical Mechanics course and was assigned to make a presentation on computer simulations. I was just getting familiar with the term "computer" having never "seen" one in Calcutta before coming to Brown University. I was totally at a loss, and was cursing myself for taking this advanced course (and even coming to the US). Being vocal, I let my predicament widely known to my friends and colleagues but other than drawing a lot of sympathy, not much help was forthcoming – nobody at Brown Chemistry was doing any computer simulations those days. I remember that one of the professors (an organic chemist) even expressed surprise at the term "Monte Carlo simulation". He however did educate me at length about where and how nice Monte Carlo was and advised me to go there at some point of time, but such advises certainly did not help my project much.

The situation was kind of desperate, as I was really at a loss to bridge the gap between the original papers and the implementation. One of my senior friends told me, "*Talk with Paul Barbara. He knows everything".*

But how to get hold of Paul? The only times I have seen him is rushing down the stairs or walking very briskly on the hall way but infrequently. He had long hairs then and the story was that he was working part-time at an nuclear magnetic resonance (NMR) company that was impressed with his ability to solve (then recurrent) problems with the NMR machine in the chemistry department. So, he was hard to get hold of.

But I was also desperate. I left a message with his group (he was doing PhD with Prof. Ron Lawler, famous for CIDNP -chemically induced dynamic nuclear polarization- a technique in NMR) that I wanted to see him. And then one day I did catch him, on his way down the stairs at his usual breakneck speed. My message clearly reached him, because he stopped after saying his usual "Hello", and asked what I wanted to know. I told him that I needed to write a term paper on MC/MD simulations and could not find anybody to help or even talk to.

Paul said "I know everything about simulations". It was such a relief to hear that! Finally, my help had arrived! But then he said, "I am very busy now. I can only spare 10 minutes." I was okay with that. Then Paul sat down on the stairs and started explaining computer simulations to me and the lecture went on for more than an hour. I do not remember now what was the improvement in my understanding, but I remembered that incident forever (but Paul himself completely forgot). Paul was truly a great human being, always helpful, ever kind, always stopping for a minute to help others, answer questions and respond to e-mails.

My second extended interaction with him was when after a gap of many years, he invited me to give a departmental

seminar at Minnesota. By then Paul was an established and a famous scientist, leading a large group. He was into many committees, and travelled widely. He was elected to the National Academy and was decorated with Debye award besides many others.

There were a couple of interesting episodes during this trip that have remained etched in my memory. One was about the importance of a fast component in solvation dynamics. At one point I was a bit exasperated and told Paul, "you do not read my papers". He looked at his students and told them, "show him". So, I was paraded down the hall to his Laboratory, and I was shown that they had two bound volumes that contained all my papers. I was truly humbled. And, the rare happiness lingered.

The third episode was after dinner at his home when, we went out for a walk near one of the lakes of Minnesota. It was a bit chilly October night. There he said something that struck me as remarkable and I repeated many times too many people. I was complaining (as I always do) about the lack of training we received at the Brown University. He then told me a gem of a statement which as far I remember went as follows. "Biman, we probably are the only two from Brown Physical Chemistry still kicking around in the international science, and we are not burnt out. May be the low key training at Brown helped because I have seen many from so-called best places to get completely burnt out".

In his own life he was a highly successful scientist. He made phenomenal contribution to solvation dynamics and electron transfer reaction at Minnesota and then carried on outstanding work on nanomaterials using single molecule spectroscopy. His work on photo-physics of conjugated polymer left a permanent mark on the field. I collaborated with him on this, and was impressed by his deep insights.

But truly remarkable was the intensity, sincerity and involvement, that he brought to any problem. This was not

always apparent to an outsider but one would in no time figure this out when close to him.

We published a paper in Nature on this topic which has been cited about 400 times. I briefly described how this work was to highlight Paul's insight and ability to arrive at the crux of a scientifc problem. Paul had some data on polarization dependence of the absorption of the conjugated polymer MEH-PPV obtained by studying each of the constituent polymers. Such a result could not be obtained by ensemble experiments. Paul was already on the right track as he told me that the distributions were too broad to be fitted by a Gaussian polymer. I then found some light scattering data from the group of Benjamin Schwartz that gave me the size distribution of the same polymer in solution. When I tried to fit those data to a Gaussian polymer, I found that the polymer must bend at every 4th monomer or so! When I told this to Paul, he immediately realized that the Flory Gaussian model would not work here. We then collaborated with Peter Rossky to perform certain simulations to confirm this intuition. Because of this work, conjugated polymers are now known as collapsed defect cylinders.

Working with Paul was always exciting! His insight and involvement with the problem was really outstanding. He was really a great friend, as already mentioned. His human qualities really came to great service when he established the Nano research centre at UT-Austin. He was only 57 when he died of a heart attack; He was at the top of his career and it was a great loss to all of us. I always remember his words I quoted above, "We are the only two from Brown kicking around in international science".

Well, we shall always remember Paul as a humanist and a great scientist. He used to tell me "Biman, I love science and scientists, I do not know why!". I kind of know the answer to his "Why". We shall miss you Paul!

9

From a teacher to students: how to handle student-teacher relationship in present complex world?

(with dos and don'ts)

This chapter is because of several suicides and attempted suicides in universities across the world. This is not a political commentary but purely a concern for students' academic life that under stress can adversely affect their mental balance. This is a tough call because it involves, interaction between both teacher and student and can be extremely frustrating. Some form of communication is needed.

Despite the internet and mobile phones, *learning is still a one-way road.* The knowledge is to be passed on personally (at least at critical stages) from a teacher to a student. This is particularly true in science and engineering but one would also imagine it to be so, in performing arts and in other areas. Even in writing, a young writer would be lucky to have advice from a senior writer, especially on course correction. Advice from the poet Rabindranath Thakur (Tagore) substantially improved the literary career of many writers and poets, and was much sought after.

As I like telling stories, I share here a couple with my readers the first one from the autobiography of Mr. Tarashankar Bandhyopadhyay - a renowned novelist and short-story

writer and one of the early *Jnanpith* award winners. In his days of struggle as a lonely young author living in a small room in Bhowanipur (erstwhile Calcutta), when he was trying to finish and publish his writings and still to make a name, he used to wait for the post eagerly. Most of the letters used to be from family, friends, publishers etc., but he wrote that with all eagerness, with all his consciousness, he used to look for just that one letter which had the Bengali letter "R" written across the left uppermost corner, within a double red line. As some of you could guess, this was the mail from Rabindranath who used to give him suggestions after reading his writings.

The second story about Leo Tolstoy and Maxim Gorky – both immortal Russian writers, is also well-known. There was once a big rumour that Tolstoy had given up writing. He was then living in a farm away from Moscow. So, Maxim Gorky set out to find what really had happened. After reaching Tolstoy's home, Gorky was informed that Tolstoy was in his farm land. When Gorky found him, the Sun was setting and Tolstoy was sitting quietly looking at the Sun. Gorky sat a little distance from him. They did not exchange any word. When the Sun set, Gorky came back to his town, and wrote a famous line "So long Tolstoy was alive, Russian literature was no orphan". So, Tolstoy must have communicated an important lesson in silence to his "student" Gorky!

The teacher-student relationship is particularly important in the final stages of research leading to a PhD, even Masters. Here success depends on the work and understanding of both the student and the teacher. The student needs to understand the problem given, work hard and in a disciplined manner to bring it to completion. The teacher on the other hand needs to provide an atmosphere, advice, suggestion, and should not be overly optimistic, especially in the initial stages.

What then, leads to extreme frustration and depression that a young student gets suicidal?

I thought over it again and again, reviewed the cases I have known. Two things stand out. (a) The sensitivity and misunderstanding of the student at his/her young age, and (b) the relative lack of these on the teacher/professor's part. The issues are complex and we shall do well to go over them.

First and foremost, our education system is increasingly producing students who are not only under prepared and ill-equipped for research, but also lack any idea about the discipline and hard work that this profession requires. They seem to think that a PhD is a linear extrapolation of their BSc and MSc courses. Nothing can be farthest from the truth. When students realize all these, they get depressed, especially the students who come with high marks in those exams.

Second stage of complexity arises from a lack of understanding of the field of research. Often students come to work in an area that they develop a passion from reading at a popular level. The area may have passed its prime a long time ago. Students need to re-align themselves without much waste of time.

I see most students come to IISc PhD Interview without any ground work about the faculty of the department. This I find bizarre in the present day set up where all it takes is an hour to browse through the web page of the department and is really unforgivable. As a consequence, they often land up with professors who may not be the most active worker and not be the best mentors. These days there is enough information available to students that should allow them to make a reasonable judgement before they join a group or choose a field of research.

A few suggestions on dos and don'ts, for students are provided below,

1. Spend sufficient amount of time in thinking, discussing with fellow students about the subject you propose to pursue. This is important at all stages. Criticize the professors as much as you want, but at the end do things that are in your longterm interest. Be discreet and do not make your of any one public. Resist that temptation.
2. Talk with your teachers, even those who are abrasive. Students often misjudge the situation and the professor. There are still many good teachers and professors.
3. Never think that you have no help. Do not despair for too long. You are not a looser till you quit, and do not quit.
4. This is a repeat advice and for a reason. Talk with senior friends/students about study and research. They are your best help. Try to form a study group. Do not mingle with idle ones, however tempting. PhD takes a long time but you need to stay on course. Improvement is slow but steady. You shall be surprised by your own growth at the end.
5. It is never too late to correct the course, at least by an amount that makes things okay. It pays in the long run.
6. Be bold. This is the most important quality but hard to come by. But boldness has a price, in that you need to be professionally strong. It is far easy to be a sycophant but that does not make you happy, and does not allow you to grow.
7. Things are NOT what they seem. But you cannot be naive at the same time. I do not want to scare students, but please remember - there is always help and that

"things are not always what they seem"

"Tell me not, in mournful numbers,
Life is but an empty dream!
For the soul is dead that slumbers,
And things are not what they seem.
Life is real! Life is earnest!
And the grave is not its goal;
Dust thou art, to dust returnest,
Was not spoken of the soul.
Not enjoyment, and not sorrow,
Is our destined end or way?
But to act, that each to-morrow
Find us farther than to-day."

[H.W. Longfellow "A Psalm of life"]

10

How to be a "system's man": successful and glorified
(Poor Franz Kafka!)

This chapter was motivated by an interesting comment by a senior colleague who was fond of the term, "a system's man". It reminded me of the famous novel by Franz Kafka where a person, our protagonist, was destroyed by a system whose strength was in its seemingly goalless existence. The chapter explores the success of a "system's man" in our society which in turn respects and loves a "system's man". But what happens to those who refuse to becomes a "system's man"?

A "modern man" I thought is someone I may someday aspire to become. Not as glorified as a "renaissance man" but it conveys the image of an educated person without superstition or racism, someone up-to-date in world affairs, someone who is not parochial and someone who exhibits grace under pressure. These days, another kind of man has appeared and this chapter is about *that special* man.

I first heard the term "A system's man" from a friend in academic administration, a famous man and therefore I shall not reveal the name. He was trying to fill a position in the administration, and was discussing various possibilities. In this context, he was appreciative of a person and made the remark "I like him. He is a system's man."

I was a bit perplexed and the words stayed with me. I wondered: what (or, who) is a system's man? Am I a

system's man? Although I have served the system in some regular capacity on and off, something inside told me I perhaps would not qualify as a system's man. The system here means the current governance system

Whenever I think of "system's man (or men)" I am invariably reminded of the enigmatic novel "The Trial" by Franz Kafka. In this story by Kafka, the poor man was practically destroyed by the system and he had no clue of the system's function or of his own fault. The main mistake seemed to be his lack of respect for the system. This implies that in the modern times, survival would need cultivation of additional attributes, as enunciated below,

Rule No. 1: ***Never show disrespect for the system in modern society.***

Kafka's story was scary. The long hand of the system robs you of your freedom. I know many of my friends take a lot of pride (may be justifiably so) for holding some administrative position. There is again a story here to tell. Recently a famous physicist was visiting India (and Bangalore) and I read his interview/comments in the Newspaper. He made the comment that he was surprised by the respect of Indian scientists for administrative positions. Whenever professors and scientists were introduced to him, they were introduced as "Chairman of …", "Divisional Chairman …", "Dean ….

Nobody was introduced as a simple professor. So, he jokingly said nobody wanted to be just a professor in Indian science! They have to "Chair" something. But why is this extraordinary respect and yearning amongst us for administrative positions? Is it because this is helpful financially? Or, is it because of the lust for power?

Such a position indeed takes away a lot of time and energy and needs the involvement of a different kind. Much of it is probably useful. But still must be inconvenient for

a scientist and artiste, especially in his/her young and productive stage of life. In many countries (like in France) professors tend to avoid administrative positions. There may be cultural reasons for that but mainly because it takes away time from studies and research.

It seems that being a system's man, seems to open up ways to be successful in a well-defined way, such as it opens gate for awards, prizes, membership of the academies. *And all these take place when our ignored and ignorant scientist friend is working away in the laboratory!*

I have several brilliant friends who remained on the side lines and were ignored in all the above decorations because they were not "system's man", and even made the mistake of showing disrespect for the system (again, "The Trial" by Kafka!).

But all is not lost! The scientist at least get time to work and follow their passion. But the situation has changed a lot in recent times. This brings me to the main point.

As the system becomes increasingly powerful (as depicted in Kafka's "The Trial" which was written just about hundred years ago but seems more relevant today), I sense that our freedom will be compromised. A truly creative man can never conforms to the contours of any system. Even when a system is sometimes built around him, he may find it hard to follow the dictats of this system. At the same time for any governance system to work well, good people are needed. And, this dichotomy will remain forever.

There are layers and layers. In the meantime, let us applaud the system's men and women who serve the system selflessly and at the same time let us also not forget the poor souls who are legitimately outside the system and let us pray for their wellbeing as well.

11

Showing up and showing off: two 'constructive' ways of securing your career

This is partly a continuation of the previous chapter but argues that showing up, that makes you a system's man, may not be enough in present-day science. In order to succeed, and to survive, a researcher needs to show off a bit. Otherwise, there is the danger that she/he shall be ignored.

Woody Allen is supposed to have famously stated that 80% of success is just showing up. I am largely in agreement with this famous movie director, actor, writer and comedian. This got me into thinking though. How important is then showing off? Also, do showing up and showing off work in tandem?

Let us look at these interesting and correlated issues, in a constructive way and see what we can come away with. In some profession showing off is important. This is certainly true for physicists in particular, and today's scientists in general. This is also important if you are a politician. One has to subtly sell his/her acumen and successes, in some way or other. One may repeatedly point out how successful he has been as a business person, or as a player of ice hockey or in fishing, or in basketball. One need not provide the names, here as a discerning reader would have guessed them. Actually, such queries can serve as good general knowledge questions. Take this one for example. Who is a powerful politician who shows off in the ice-hockey field? You can easily form many such interesting questions.

There are important lessons for today's students here, especially for PhD students.

The student should certainly show up in group meetings, departmental seminars, conferences and lectures. Then, if opportunity arises, even better if one can create an opportunity, one should not hesitate in showing off his intellect by asking serious questions to show that one is smart, attentive and knowledgeable.

A PhD student has many roles in a department. They are expected to be active members of the academic community that should participate in deliberations. The quiet student might be thinking as to why should he/she care? But quietness and humility seldom pay. You need not be arrogant but should be visible. You need not only be good, but be obviously good.

Now back to the main theme of the write up. In my long professional career I have found that, successful people are those who both show up and show off. In the modern, not-so-fair world, even successes with grant proposals depends on these two.

Once I asked a young colleague the reason for his travelling so extensively and for going to all the conferences. My young colleague flatly told me that if he did not show up, he would not get grants.

That did not make too much sense to me then. Because I, for one in my early years used to decline most of the invitations. This certainly harmed my professional progress but I could care less. In addition, I was not fond of spending time away from home. I went to several long trips but tried to take my family with me. From India going to ACS and APS meeting were very expensive, and I thought these trips are waste of money and resources. But the time has changed and so have the value systems.

So, my advice to young students and colleagues: Do show up and show off, even if you do not like to do it. It is not easy. It requires discipline, certain practice and acumen, and of course smartness. Also, be nice, very nice. That helps. You need not to be very humble but need to be real nice to one and all around you.

May be someday the value system will change again for the better when all the self-propaganda will not be needed. As one of our distinguished professors once stated "I do not want my science to be sold as a tooth-pick".

12

Rapidly changing face of science: how to cope with it while working in India?

Scientific research has evolved at a tremendous pace during the past two-three decades, particularly in chemical and biological sciences. Information is often disseminated through conferences and seminars. Thus, you find that at a major university in the USA there are multiple lectures/ seminars on the same day, many visitors that one can interact with. The same is lacking in India. Our young generation may find it hard to remain engaged with the change. It is pointed out extensive reading still remains the viable option in India as our students do not get the opportunity to listen it to international seminars firsthand. However, the recent emergence of internet and online seminars may help considerably.

We see all too familiar patterns around us – I have now seen them for 35-40 years. A bright energetic young faculty joins our ranks after a PhD and/or a postdoctoral training, overseas. This young and enthusiastic scientist starts a new research programme which is in the front line at that time and, is being much talked about and discussed. Contrary to our earlier times, now grants come a bit faster and in substantially larger in amounts, so initial take-off is not so bad.

This scientist also performs well, publishes good papers in good journals, for several years, may be even for a decade or so. But then another familiar pattern sets in and now not-so-

young scientist loses his/her way. In these days of rapidly moving and changing science scenario, his research is not fashionable any more. He finds it difficult to feel excited, publish papers and even to find good problems (except in fields like nano-science which seems to continually reinvent itself).

I shall exclude from my discussions those scientists who frequently jump onto the bandwagon and manage to publish a lot of papers in a short time but hardly make a meaningful and lasting contribution. Sadly, this has become a common trend in science these days.

Why does it happen all too frequently; the failure to reinvent oneself, even when time and opportunity both exist? This happens more frequently in India but probably elsewhere too with regularity and many senior scientists/professors discuss these issues in one way or the other. Contrastingly, there are several researchers who have worked/been working on the problems they learned during their post-doctoral tenure.

Let me now tell you a different story. During a recent visit to several laboratories abroad, I was fortunate to work with a few outstanding scientists. A common characteristic in them was that they read a lot - even when they are very busy and very active — they read an enormous amount, probably even 20-30 papers per day. I do not mean they read all of them but they took a print out and spend at least some amount of time going through them and assimilating their key message.

Such huge effort in a continued manner, certainly arises from one's innate curiosity and from an ardent desire to keep himself informed about the happenings in different areas of science. This is also discipline. A common trait among creative people all around is that, they read a lot and on varied themes. We know this. But there is a difference with science, where this reading is deliberate, and is a work!

I see very few researchers taking such pain (and pleasure) in going through the literature with as much thoroughness , as is done by in some of the outstanding researchers. Even I have stopped doing it myself rigorously as I used to do it in my earlier days.

Bertrand Russel said, too much reading rots the mind. I subscribed to this logic for some while, but much to my own peril. Russel was wrong, possibly absurdly wrong!

Zwanzig used to tell me "Do not write for Professors, they will neither read nor change. Write for students and postdocs".

And, therefore, I am doing the same, sharing my experiences and observations with the students and young faculty members. Never give up reading if you want to succeed in science and more importantly want to remain engaged. It is worth it! It will be fun one day.

13

The apple does not fall far from the tree and the academic families (like teacher like student?)

Here we address the issue of continuity of research and the outlook of students graduated from a group. Famous groups often produce students and researchers who continue to work along the same line as trained by their advisers. There are advantages but there are also dangers. However, when one acquires certain good qualities it can become a boon. This point has been illustrated with examples.

The Apple does not fall far from the tree - so goes a popular saying, often applied to family characteristics but I think it also applies to academic families. Not a terribly new thought, but worth some musing, especially in the context of Indian science where such families have formed for the first time. Some professors are particularly active in building their family tree. Students of a family often work on similar problems, and stick together and promote each other. Not always, but it now is a frequently observed pattern. Hence my use of the quote "The Apple does not fall far from the tree".

It cannot be denied that students do acquire certain aspects of the value system of the adviser. If the teacher professor is honest and scrupulous, students tend to be honest and scrupulous. If the professor is hard working, students value hard work. The opposite is also true. I know from first-hand experience that some students are unfortunate to have acquired negative values. When the professor is

a troublemaker, his/her students often turn out to be the same. May be the bad values/characteristics are picked up more easily? Maybe it is very hard to induct good virtues?

There have been professors who have been particularly impressive. In Chemistry, Linus Pauling has an impressive list of students. I would mention Martin Karplus as an example. Martin Karplus has produced impressive students such as Peter Rossky, Atila Szabo, Iwao Ohmine, Andy McCammon, and many others. I once asked Professor Karplus what is the secret of his success with students. His humble answer was that he was the only theoretician at Harvard Chemistry those days doing the kind of theory that students found attractive.

I found many of the students of Prof. Karplus are also humble, soft spoken. Interesting similarities. They all are different in their personal lives, but seems to bear that common signature. Of course, all of them (my friends) will probably disagree with my observations.

In India Professor Sadhan Basu produced impressive students like Mihir Chowdhury, Animesh Chakraborty, Sunil Poddar, Ashish Chandra. I myself attended his lectures during my MSc years. He was magnetic. Full of vigour and had a tremendous insight. When teaching Bohr's theory, he said, "science is science, philosophy is philosophy and science is not philosophy". He was arguing against metaphysics. He also taught us polymer chemistry (mainly the physical chemistry aspects) and photochemistry. I am still grateful to the insights he provided which helped in my PhD research. A generation remains grateful to Prof Sadhan Basu.

The famous Professors J.N. Ghosh, S. Bhatnagar, J.N. Mukherjee, Homi Bhabha, Vikram Sarabhai all produced outstanding students who played stellar roles in academics of post-independent India. I know that in naming a few, I

have missed many of the deserving names but that is not deliberate and the list is only indicative. If it turns out that if your professor (commonly referred to as boss in student lingo) is not the ideal role model that you wished and deserved, do not copy him. Be conscious and conscientious. One does need a role model to build yourself. Remember the story of *Ekalavya* in Mahabharata? Look around, you will find somebody who has a strong academic values and integrity. No revolt or strong dissent is necessary but slow orientation is all that is needed. This will do you good. And, for sure, one shall be proud of himself, one day.

14

Serious people are winning the world over
(and humour is a dying art form)

Let me start with a personal story. I was once talking to a friend, a famous professor, at the University of Chicago. There are of course many famous professors there so the identity won't be betrayed. I was praising a colleague who visited this professor's laboratory for a few months. I said, *the guy (the Indian colleague) is quite hard working*. There was no response. I continued, *he spends a lot of time in the laboratory*. Again, no response, but I did not give in. I then said, *He is also serious*. Now my Chicago professor-friend erupted and in an irritated voice said, yes - *much too serious*". He, then calmed down and added with a smile: unlike some other Indians I know. The last one was meant for me.

People all over the world have become (or are rapidly becoming) much too serious, and writers of satire and humour have gone into exile or extinction. The genre of Sukumar Roy and Parashuram (in Bengali literature), Lewis Carroll, Mark Twain, Nikolai Gogol (Government Inspector), Chekov are declining and we miss them dearly. Certainly there are quite a few in many Indian languages but sadly we do not get to read them. My non-Bengali friends often tell me about them, but it is hard to get their writings, and we lose much of the flavour when translated. It is a tragedy. Of course we all remember the stories of the naughty yet lovable boy Swamy (and his friends) in Mr. R.K. Narayan's stories.

Century old tradition of a group of well-meaning lazy intellectuals without ambition but with a realistic (meaning cynical) world view, gathered in literary joints and coffee houses, is dying or already dead. Long gone are the days of Socrates. How great must have been to gather in a place (of course after a good meal) and engage in enjoyable discourse till it was time to go home for another fill! I gather surrounding people were not too averse to those intellectual (lazy) geniuses. Socrates was one of them.

When we were growing up in Calcutta in the late nineteen sixties and early seventies, we saw all around us *adda* (a den) of grown-ups. In my home, my elder brother was very fond of and was a regular attendee of a couple of such *adda*, even after he started on a regular job. He used to run to those immediately after returning from work, to what he used to refer to as his oxygen. Being engaged in *adda* was a matter of pride and was never looked down upon. The topics they discussed ranged from movies to food to politics to scandals to sports to literature (no science, except trips to Moon) - that is, everything under the Sun. He used to come back in really good mood, with a good appetite for dinner, and some new information. I gather from my reading that poor Socrates did not have such a good time as his wife presumably did not treat him well. But in Calcutta, wives did not quite mind their husbands to be away for some time, instead of creating nuisance at home! Those days were different – men were men and women were women!

I must admit that I have a reserved affection for intellectual idle ones. They stand out from a large number of serious, self-centred people (the go-getters) around us. They often live in a world of their own. They are usually not damaging to the society as they do not have the energy to go after people. As I mentioned it is the over-ambitious energetic power hungry people who get corrupt and then do the most

damage to the country and society. Power corrupts people and absolute power corrupts absolutely. May be the world wars were fought because of ego, ambition and profit of a few individuals. Only a few. This seems much worse than the small wars. The Athens and Troy fought over Helen. Of course our Ramayana was also such a story but ours were more religious and kind of war was of the right over the wrong.

Coming back to the central theme, the picture of hordes of serious people roaming over Mother Earth is quite repugnant to many. Bangalore roads are full of them. Why are people so serious? It is almost criminal.

Let me make my case against serious people. They always want to get jobs done in a hurry and are pushy. Admittedly, nothing would get done if we do not have serious people. But we should limit serious people to the area of medicine and food production. You certainly do not want your surgeon to be a lazy philosophical genius. He might stop to think in the middle of a surgery, like Niels Bohr did during a soccer match. He presumably stopped the ball, picked it up in the middle of the play (when he was expected to pass the ball or score a goal) and calmly studied the pattern. Those who do not know, the surface of a football is divided into hexagonal and pentagonal rings such that they cover the surface completely. He was probably studying the curious pattern that later came to be known as the Bucky Balls (or, the fullerenes), discovered in the late 1980s and the discovery received a Nobel Prize in chemistry. So, Neils Bohr was intrigued, probably thought of the uniqueness of the pattern before others but his behaviour certainly did not amuse other players in the field.

But for sure I would not want a surgeon to make a discovery on opening my tummy or whatever parts they open up. Also serious people are needed in the transport business.

One would hate to have a lazy person as a pilot but this is less of an issue if one does not travel. Certainly, the serious people travel far more than most philosophers who neither have money nor energy.

To sum it up, my thesis is that much of the problems of the current world can be attributed to an increase in the number people who take themselves too seriously. Look at social media and also the big malls. We knew that women take their looks seriously but given the freedom the extent they are going is amazing. Now men have also joined the "band wagon." --- I see so many fancy young guys during my walks in the Sankey Tank, with fancy shoes (colored red or green), fancy hair cut, and not to speak of fancy T-shirts.

If you have an alternate view, I would like to hear about it. Till then I would assume that I am right. We need more number of well-meaning idle but intellectual persons among us, who with their humour and satirical cynicism would make a better place to live and perhaps make it more peaceful.

15

The danger is not that we aim high and fail but when we aim low and succeed

We often see highly active and gifted people running after relatively minor things, like small awards, recognitions. Money is of course something that always attracts people. Here I discuss how even mighty ones fail because of low goals. This is a bigger danger than aiming high and failiing.

A famous quote by Michelangelo says, the greatest danger is not that you aim high and fail, but that you aim low and succeed. (paraphrased for simplicity). This is poignant with meaning, and so appropriate to modern science, particularly so to Indian science.

I remember Professor S Chandrasekhar giving an interview to Kameshwar Wali (mentioned in Dr. Wali's well-known book "Chandra: A Biography of S. Chandrasekhar", Centennial Publications, The University of Chicago Press, 1990) where he observed that during the 1930s in Kolkata, there was a wide-spread feeling among scientists that great science could happen quickly and simply, flowing easily from a single brilliant idea or original thought. This belief again was rooted in the success of S.N. Bose, C.V. Raman and several others. Professor Chandrasekhar went on to mention that his own perception of science and the realization was that you need to work extraordinary and persistently hard and this realization came to him after arrival at Cambridge University, UK.

In India, young researchers are often trained to focus on quickness and "easiness", but without the necessary focus on the brilliance or originality of the aforementioned scientists.

To an extent two points above have kind of got mixed in today's world of science in India, particularly so in chemistry and condensed matter physics where publication in large number in good journals is considered to signify success. May be this holds also for Biological sciences. Such an approach with over emphasis on the number of publication does seem to succeed in short run – in terms of awards and other aspects of career advancement, but in the long term and in terms of science, everybody loses.

Let us discuss this point a bit more. The problem of publication oriented research has two facets, viz., (a) one works on projects which are fashionable and those that fecilitate quick publications, (b) the papers are published as soon as the results arrive, without much checking, reanalysis and thinking. There is nothing wrong in working on a fashionable problem, although scientists like Feynman, Gibbs and others, advocated against this. In the famous letter of Feynman to his ex-PhD student, he wrote (I quote verbatim, but italics are mine); "It seems that the influence of your teacher has been to give you a false idea of what are worthwhile problems. The worthwhile problems are the ones you can really solve or help solve, the ones you can really contribute something to. A problem is grand in science if it lies before us unsolved and we see some way for us to make some headway into it. *I would advise you to take even simpler, or as you say, humbler, problems until you find some you can really solve easily, no matter how trivial.* You will get the pleasure of success, and of helping your fellow man, even if it is only to answer a question in the mind of a colleague less able than you. You must not take away from yourself these pleasures because you have some erroneous idea of what is worthwhile."

If we probe deeper into the meanings of Professor Feynman, it is the question of attitude, and that's what really matters. This has a very important consequence for students and young researchers. They do not learn to think deeply.

The philosophy of "do what you can put your hands on" runs against the very basic ethos of science. It then becomes more like publicity. One often hears people glorifying the number of papers they have published where they should actually be proud of the few new ideas and concepts they might have had introduced. There of course is the unsettling possibility that people who publish a lot know it all and still do it. After all an old German proverb aptly said, "Nothing great can be done in a hurry". In the end, it may be worthwhile to realize that in the long run, the quality of what you write is more important than how much you write and where you write.

16

What is the most painful part of being a Professor at the Indian Institute of Science (anywhere in India) today?

This chapter deals with the acute problem we face with students entering research stream due to their acute limitations in communication. Most students do not know how to write correctly and coherently. I provide a few guidelines that could help the students to acquire necessary skills for a career in science.

This chapter is neither pleasant nor funny. But it is true.

Speaking candidly, it is correcting the English written by students and, additionally, teaching the students that you cannot have "is" after "I". It is not "I is", but "I am", not "you goes", but "you go" , is a frustrating experience. Do not use present participle for work done one hundred years ago, do not mix tenses (at least within a paragraph) and so on. Well, I might have exaggerated a bit, but it is mostly true and the message should be clear.

Given that communications through reading and writing is cardinal to academic success, failure to write meaningfully is can be appalling. And, this needs due remedial actions by the students themselves. Otherwise they are doomed in academics or elsewhere.

My father, an English teacher, used to call such English as "sinking sinking drinking water" which was a direct (word-per-word) translation of a Bengali idiom (*dube dube jawl khachchhe*), meaning one is doing something secretly. The verbatim translation was interestingly and appealingly funny, and students actually enjoyed it. The translation also made it clear to the students the mistakes they were making in their construction. Each language has its own peculiarities and idioms, and we must be careful in following the flow of a local language when translating into English or any other foreign language. This point was made aptly by the famous Kannada novelist, Mr. U.R. Anandamurthy who once remarked that when he read the English writing of an Indian, he could tell the mother tongue of the writer. While there is probably nothing wrong in this, it seems to me to limit the reach of the writer.

I see such "sinking sinking drinking water" English every day among students' writing. Even today morning I corrected the following sentence in a paper "Using Eq. xx and putting Y=Z and then Fourier transforming, getting...".

Another illustration of inappropriate English, I corrected this morning is the following: "In order to achieve xx equation, the formalism are ...". Well, who is to convince the student that you do not "*achieve"* an equation and you do not have "*are*" after formalism! See how "sinking sinking drinking water" comes out so frequently in writing?

As I discuss below in more detail, the only way to improve is to read English literature and read as many books of varied kinds, as one can lay your hands on. Experience suggests that many Indian students are well-versed and well-read in *regional languages*, but have minimal exposure to English literature. This was not so in the past. One read the books by Ernest Hemingway, Charles Dickens, some of William Shakespeare, Mark Twain during College years. Pablo Neruda and Camus were our favourites, along with

Kafka. In Calcutta, Gorky, Gogol, Dostoevosky and Tolstoy were house-hold names and were read mostly in English. A lot of books were exchanged. A friend, Parichay Das (who became a chemical engineer), always carried the books of Neruda, Hemingway. I forget the names of many others.

Our teachers at Brown and elsewhere told us (when they saw our difficulty) to read simple books. Bob Zwanzig always suggested that we read "The Bible" and children's books to learn how to write nice, simple but elegant English. We all had to go through a difficult phase where we worked at improving our communication skills, our written English. I had a great friend at Brown who taught me many nuances of English speaking and writing, often after 10 PM, in the Metcalf chemistry building. He used to do laser experiments in the next adjoining laboratory. He was an incredibly bright student who scored 100/100 in every examination, but he took time off to correct many of my errors in English.

I also remember my suffering during the first paper that I wrote. My adviser corrected it in red ink (quite unusual) and when returned to me, I was crest-fallen. He was ruthless. He coolly told me, "your number of articles is more or less conserved; *just they are in wrong places"*. By the time I went to work with Bob Zwanzig (who was regarded as one of the best writers in our field) I had improved to the extent that Bob complemented me on my writing skills.

I am aware that my English is still imperfect and I am conscious of the limitation of not being able to write good English but I have a few secret weapons that I shall discuss some other time.

I am stating all these because despite repeated suggestions, requests and corrections, the situation fails to improve. I tell students repeatedly to read grammar books like "The Elements of Style" by Strunk and White, now available easily, but no visible effects are evidenced.

To reiterate, the only way to improve language skills is to read English literature. Thus, my advise to students: Read, Read and Read. A catastrophic consequence of this lacuna (not reading) is that even good students are tempted to copy from multiple sources, leading to the charges of plagiarism which, now almost a criminal offence. It is easily detected and the students get black-listed. I also sense that students now are greedy, looking for quick publications even in the first year with scant regard to quality and originality.

To summarize, a first dictum would be: *Read, Read and also write*; read not SMS or comic books, but real good books, classics. All-time favourite authors are Ernest Hemingway, Charles Dickens, Mark Twain. This advice may appear to be a bit snobbish, but one gains so much more by reading these authors, besides the English. Second, one should read the "little book" by Strunk and White: "The Elements of Style". It is just about 80 pages and very smooth to read. You will like it. Read it again and again and again. Keep a copy on your study table and another under your pillow. Third, you must write. Write whatever you want to, but write. May be you should start with a personal diary. The idea is that you need to practice away from your scientific writing. I am not sure how much arithmetic you would need in your future life, but reading and writing shall form an integral part of success in life as long as you are in academia. It is a good habit to write a synopsis of every paper that you read in one page. This will not only assist you with the writing skills but these notes will be handy while writing the thesis.

Fourth, improve your vocabulary on a daily basis. At time use of a proper word can replace a sentence and make the presentations, as much more eloquent and enjoyable.

17

Facts, information and agile thinking

"It is a capital mistake to theorize before one has data. Insensibly one begins to twist facts to suit theories, instead of creating theories to suit facts."

— **Sherlock Holmes**

Facts and information stand supreme. However noble Sherlock Holmes may sound, it is hard to apply this to some disciplines like biology where facts are enormous. The chain of information is mind boggling. Inadvertently, therefore, one begins to theorize before one can assimilate or gather all the facts.

These days I am trying to learn at a somewhat "forced" rapid pace about the intricate processes of molecular biology. For example, I just learned about the role of EMT (Epithelial Mesenchymal Transition) in cancer metastasis, and the hybrid form that seems to be the real culprit. I learned about the microscopic processes that might be happening to facilitate transport across narrow tissues. This was exciting but all the terms were new.

As if this is not enough, I am now having to learn the role of mutations in the receptor of proteins in the cell surface. I also learned about possible pathways which curcumin might block, resulting in the slow down the progress of prostate cancer. These two are connected but I will not get into the details.

I have deliberately given the above examples to emphasize the amount of information one needs to assimilate in a relatively short time so that one can use them in a research mode to understand a few aspects of Cancer. I learned a lot from a young PhD student at Rice University's Centre for Theoretical Biophysics (CTBP) and without his help I would not have been able to pick up the few things that I did. I noticed the ease with which he assimilated all the new information and I felt like a dead stone. Man, this is what ageing does to you! But even without the ageing process, to me assimilation seems to directly interferes with our abilities to think.

One is used to these processes/ actions occurring simultaneously: thinking, assimilating while working and employing what was just learned. This is like learning a new mathematical technique (say a new differential equation) and applying it almost immediately to solve a problem. This natural process seems to occur effortlessly at a young age. But now I am being forced to learn first, then think, and then hope of applying the new knowledge in near future. Of course small bits of thinking and imagining can always go on. But the intensity of the young age tapers off with ageing. Often statements are made to the contrary, especially by senior scientists, but the fact remains a fact.

Yet, one needs all these informations to pursue a small hypothesis he has. But that seems far, very far indeed. In the present case of cancer, I miss the green pasture of well-defined problems of chemical physics where we know why we cannot crack a problem.

This raises the question: does too much information confuses us to the extent that one cannot think properly? And, if we seniors are so confused then imagine the plight of the students? Are we not asking them to give up thinking and be a robot?

Is this the syndrome we see in most of our new students who suffer whenever we ask them to think? A student after her PhD Thesis told me that she was paranoid when I told her that her job as a student was to think, think and think! She told me that that was the first time in her life that a teacher insisted that she must think first.

Of course, this ability varies from student to student. Some students seem to be capable of the handling flow of information, and know how to use the new knowledge well. However, some others may find it difficult. They then get confused, demotivated and stop being productive.

What makes the difference? We do not know. The students who are capable, are not just smart but also somewhat bolder than the rest. These students face the barrage of knowledge and have the confidence to by-pass the ones not needed. They do not get carried away. So, boldness is virtue, that helps.

Students, in theoretical sciences, need to learn about computer methods, simulations, numerical approaches and write sophisticated codes. These must occupy a lot of their time, mind and thinking. But ultimately they need to return to the fundamentals like, analysing a time correlation function in terms of microscopic processes, so as to make sense of the results from simulations.

I see the students falter in this later stage. They seem to learn the computational aspects quickly but then, something snaps and crawling starts. Can we blame them? As the students are required to process more and more information, their thinking ability depletes, non-linearly.

What about their creativity? We need to worry about this. In the USA and in Europe, a solution to this problem seems to be taking shape. The students are sent to many conferences where discussions, listening to many lectures help the process of knowledge gathering, and at the same

time they can experience the manner in which the scientists think and work. This is almost entirely absent in the Indian scenario. This is perhaps what referred to as "science by the have-nots" (Ahmed Zewail).

The situation has not changed much over the years. Earlier we did not have access to the information about the latest developments. Now we do have the internet but we do not have means and expertise to screen the enormous flow of information. Besides, there is an ever dwindling number of scientists in each area.

Feynman offers a solution. He mentioned that some of his success came from a 19th century mathematics book that his teacher gave him to keep him engaged. That old book taught many tools not known to his contemporaries, like to how to differentiate under the integration sign. Here is an example of the use of a mathematical tool picked by venturing out of the way.

18

Succeeding in science

This chapter is for young faculty and PhD students, but others are also encouraged to read.

We are now used to the new-world idiom "nothing succeeds like success". This to an extent implies, that the end justifies the means. This is probably not good for science ethics and scientific values. But this brings out the strong desire in some people for success. Somehow we have managed to define success in science with certain definite measures. In fact, many young faculty members truly, really, innately and ardently believe that success means getting awards and promotions. The model of success in business has slowly pervaded science.

Then how about succeeding without any success? The emergence of a new paradigm? I am not being sarcastic; I am actually serious and realistic, may be a bit wistful.

Sometime ago I wrote a piece entitled *Where weakness is strength* in the journal. These two are related, particularly applicable the Indian context and surely for chemical sciences. It may hold for other branches of sciences.

Let us have an open mind and study this phenomenon. In the present day context, there is a method of doing science. Probably, there is some merit to it and we need to study the method. As mentioned above, there is a group of scientists who have become famous and powerful by being famous and powerful. Sometimes we joke about this by stating that there are a number of people who are famous in India

but unknown outside. I guess this happens everywhere and we need not complain. I also mentioned that they serve a purpose. And the students must take these people seriously because such scientists determine jobs and future of students. And one does not see any hope for a change in the horizon.

The fault lies with the system. The country has far too few scientists in any field who are qualified to judge outstanding work and also, there are a far fewer interested and informed in areas outside their own research. When I was young I intuitively knew who was a good scientist: through a short conversation, listening to ones talk, reading a paper was enough! Also good scientists, are rarely interested in the administrative work. It is a sacrifice they were/are reluctant to make.

But how all these induction into non-scientific or administrative work get started on a scientists life? To understand, let us start with the initial phase of professional life of a young scientist who has just joined a university or an institution. An ambitious person immediately sees and feels a power structure around him. He feels the need to become a member of this power club. This pressure can be enormous and may mean going out for coffee five times a day. One needs to appear (at least) as a member of a politically powerful group.

Here, the young scientist may fall into a trap. Many of the politically powerful people in India have stopped pursuing science quite some time ago. Once upon a time, they were good scientists and have carried this glory despite having become scientifically less productive. In most cases students and post-doctoral fellows do the work. Such senior mentors are neither emotionally involved nor have the requisite passion. It for sure needs courage, self-confidence and dedication to avoid the peer pressure. But the problem is

that merit and even good work often goes unrecognized and unrewarded.

Another problem in Indian science now is the extraordinary emphasis one publications. This is certainly a case of nothing succeeds like success. My advice would be to be as creative, and as hard working as possible. One needs to be sincere, even at the expense of appearing unsmart. It is okay to appear a bit dull sometimes. But being sincere shall keep one on the trajectory of academic growth.

In science one must grow, learn new things, and seek newer avenues. Bob Zwanzig always advised us to learn as many techniques as possible and he was learning new things even at the age of 70 years. He wrote a 2-page note on this, which was published both in the old journal Kinam (now disappeared) and also in J. Statistical Physics.

One need not worry much about small awards. This may appear to be a strange advice, but one can trust these words. These things do not matter in the long run. There is a lot of merit in the saying that, Work is your main award/reward. And, do trust these words.

One's sincerity and involvement will eventually show up in his work and papers. Note that life is a marathon, and the end does not justify the means. But the end still matters. As Rabindranath repeatedly emphasized, it is more important to get the respect, affection and admiration of the near ones (who judge you better). In Science this means your own peer group and may be colleagues in your own sphere. Let me tell you that very few achieve this goal, but it immensely is worth it and more satisfying.

19

What it takes to be good and effective in personal communication and why it is so difficult (yet important) in science?

Many students and young researchers are poor in communication at a personal level which though an important and integral part of success is often ignored as a part of life-skill. Hence this chapter.

These days, words of mouth can move a mountain. This was said by Arundhati Roy. This idea expressed is both brilliant and apt and, applies to every profession.

The idea to write this chapter came to me after listening to several seminars by faculty aspirants. Many of them gave nice presentations, with interesting results and graphs. Questions were well answered – overall not a single bad performance that I have come across from job seekers in recent times. Things have improved a lot from the times we went around giving job talks. Now the speakers/candidates are more aware of the need for a better presentation. However, the problem really arises during one-to-one discussions. The same person who comes out bright and energetic on the dais, appears to be ill-prepared, and not so well-informed within the confines of a room, in a more informal setup.

Let me give some concrete examples. During the course of such a discussion, the candidate kept referring to his group

at Utah or Arizona (or, wherever in the USA) as "us", "we", "we are doing the best work.", despite his having left the group several months ago and was now back in India for good. He failed to realize that the reality for him has changed. Such a close association with one's ex-group (even though the candidate was an Indian PhD) does not speak high of one's independent thinking and attitude.

Second example; the candidate became quite garrulous and started commenting on scientific standings and abilities of several scientists many of whom are well-known to me. It immediately showed the immaturity of the candidate. A young scientist is not supposed to be bothered about all these, let alone share his opinions.

Third example; most of the candidates when they enter faculty offices, speak a few flattering words about our respective sciences. But when probed a little deeper, they fumble. What I say is that often for a useful) conversation and communication, the candidate needs to prepare. It is therefore surprising that many show up for jobs at a department without any background work on the department and its faculty.

Of course, a leader is a person who is a great communicator. A great example from India is our Honourable ex-PM Mr. Atal Bihari Vajpayee who was exceptionally articulate. Another example is the ex-US President Barak Obama. What a skilled communicator he is! I love listening to his interviews and speeches.

In addition to job hunting, communication is important in establishing collaboration and contacts. Another important thing that, many young students and faculty forget, is that humility is a powerful force in communication. Sarcasm never works and is counterproductive. There is no need to appear super smart. That never helps. If you are already good, remember what the great Philosopher Nietzsche

said: Arrogance on the part of the meritorious is even more offensive to us than the arrogance of those without merit: for merit itself is offensive.

To communicate well, learn to listen. This is oft advised and is in many public relations books, but few follow such advices. It can be seen that minds stray when others speak.

During a conversation, a lot of nonverbal communication also goes on. The look in your eyes, curve in your mouth, bending of shoulders, the movement of your hands—everything sends a signal to others opposite to you. The best way always is to try to stay as engaged as possible when the other colleague is speaking. When it is your turn, keep a close watch on the colleagues opposite to you and try to decipher their mind which is often not difficult because he/she also sends the similar signals.

Personal communication is like a game that two or three players play. I was once a member of a small group at a party that stood around an attractive young girl who was then a post-doctoral and was soon going to be an Assistant Professor in a major university. She did much of the speaking, looking at each of us in turn, and we stood in complete attention. She really knew how to communicate and hold attention. She was also a good scientist who went on to become exceptionally successful.

At the end, it also requires a lot of courage because one is often afraid to say important things, for the fear that it may be misunderstood and that it might hurt both, self and others. Words are important and also, how one uses them to express his thoughts. Fruitful communication at a personal level is an enormously important skill that can go a long way in securing your scientific career – your job and progress.

Practice it!

20

Fast outside, slow inside?

Tradition is often a good thing but one sometimes notices that traditional beliefs are at odds with scientific thinking. Sometimes even an individual himself or herself does not know the baggage one is carrying into his academic life. This baggage slows one down, especially so in science.

Today I received a mail from a well-known university in India containing a cheque of a few hundred rupees for a service I rendered a year ago or so. It came in an old brown envelope, with hand written address. It was stapled in so many places that we had to tear it open. It reminded me of the letters used to get from my own university 40 years ago. It brings home the stark message – nothing has changed in the Indian state and central universities in the last 50-60 years, probably all through our Independence – may be even from Sultan Babur's time!

It is truly amazing to see as to how offices in those universities managed to remain the same among the rapid changes that go around them (internet, mobile, apps, etc.). It reminded me of a story I read in my childhood. The story had the title "The same tradition continues" and was quite revealing and went as follows.

A young person knew a man who ran a grocery store and lived in the adjoining quarters . The man read Ramayana to his 8-9 years old son every day. After a few years the young man (the author of the story) left the locality for a job. He returned after retirement after 50 years. One evening while walking back from his everyday stroll, he found the same

old thing being repeated and he was so surprised by the image from 50 years back. He almost fainted as he first thought that he was hallucinating. After gaining composure he realized the 8-9 years old son in his childhood image is now the father reading Ramayana and the son is the next generation. The author of the story felt positive about the continuity of tradition but to me it meant that these families have resisted change. And, five decades is a long time, indeed.

We often take considerable pride in the traditions. Tradition certainly has its place in social and religious spheres of life, but what really is tradition?

In the movie "Pink", starring Amitabh Bachchan, the same issues were raised. What goes in the name of tradition might not always be good for progress? In the said movie, the antagonist justifies many of his actions in the name of tradition and traditional male values. I would encourage you to see the movie.

Thus, when any society follows tradition without due understanding of the current context and their origins, then its progress gets hindered. A person who believes in tradition, tends to follow the same path while a more liberal person seeks out new avenues and newer paradigms. One must assess the contemporariness of a tradition before accepting it without a reason.

A country where we do not hear of such traditions is the USA. You may say that they do not have a history or traditions. But one cannot deny that the second half of the twentieth century belonged to them entirely, and this continues even now. Very few societies have made such an impact as the USA. I find that among my students, the mediocre ones are more traditional. They are overly respectful to teachers, and are often bereft of new ideas.

Generally, the bright ones are less traditional, challenge me and are more successful in research.

The central point of my chapter is that, when a society pays much too much of a respect to tradition, it loses the creative, non-traditional students. Consequently, the society itself suffers. The society knowingly or unknowingly discriminates against the non-traditional and unusual students. In India, we do expect students to behave in a certain fashion. We train them to be respectful.

A story told in Robert Jungk's famous book "Brighter than a Thousand Suns" is revealing. The great German physicist Arnold Sommerfeld started every class by telling his students that, there is a wall in front of you which is to be taken down., implying that old theories and concepts need to be dismantled. **One cannot be a scientist if he/she is too respectful. One has to be a little rebellious, seek new paradigms, and ask probing questions, even when it antagonizes the teachers.**

21

Without early training and exposure, we are sending Indian research students on a steep downward path in science

Some chapters are more fun than others and the present one is anything but fun. It is downright sad and is on a topic which makes me angry because this can be amended with some effort. Anyway, please read on.

A few days ago I received a phone call from an ex-PhD student of mine who is now a full professor and is an established and a well-known scientist. This young faculty had been to a Faraday Discussion in England. During the course of conversation, she pointed out that it is futile to blame our students for failure in recent times because our students are hardly prepared for research. Our students are saddled with fairly useless but intensive studies of 5-6 years of the same bookish memory-based training that was in vogue 50 years ago. In Europe, there are now, for the last 15-20 years at least, an increasing number of schools (summer schools, winter schools, autumn schools – you name it) that train young students at undergraduate and higher levels, to advanced methods of research, by scientists who are acclaimed professionals. In these schools, teaching and training is intense and sincere. Clearly, a new tradition is at work there. This is combined with much better schooling from the 7th or 8th grade.

Science has progressed greatly in the last 50 years. Let us take the case of computational chemistry, a subject that has become an essential tool in chemistry, biology and materials science. During the past two decades, this field has undergone a complete renaissance with significant improvements, driven by rapid advances in computational speed, storage space and related peripherals. Sophisticated techniques and programmes for free energy calculations in complex systems, calculations of the rates of reactions and rare processes, quantum chemical calculations of large molecules, molecules on surfaces, and many other complex calculations. have been developed. Progress has been manifold and vigorous. Many new packages have appeared. These include GROMACS, Amber, Gaussian that are now robust. Successful use of these techniques requires a rigorus training.

The other area that has undergone a great development is spectroscopy, fuelled by rapid advances in laser technology where, the developments traversed from nano to pico to femto to atto scales during the past two decades. To continue with this specific example, our science students come to the PhD programme without knowing the very basics of computers and spectroscopy. The students from the state universities and colleges have hardly set their eye on a desktop. They may possess a laptop or may have at least seen one but their training has been limited to word processing, internet and, may be Photoshop. Nothing that trains them for a professional career in science was taught to them. Our young generation has a better chance of becoming a player than a Nobel Prize winning scientist or achieving that calibre. We are giving them no chance what-so-ever.

Students do not get a chance to develop their perspectives. In Europe and USA and possibly in Japan, students are exposed to these fields in high schools. I knew of a paper

co-authored in 1980 on percolation theory by a student who was in 12th grade. I also know of high school students who attended higher level classes at the Stanford University.

In scientific research, especially in theoretical research, it is either one or zero in respect of accomplishments. One needs to be good and has to perform at a highest level to succeed. Unfortunately, even highly gifted and talented students do not get a fair chance to succeed in today's exceedingly competitive research ecosystem. The students perform as they are told by their guides. The teachers get frustrated with the lack of originality. May be a glimpse of some talent begins to show in the 4th year. It is both depressing and saddening, to say the least!

The least the country can do is to start a large number of specialized schools where, talented and intellectually hungry students can pick-up concepts and techniques and it is my conviction that they will do it pretty quickly.

Another alternative comes to mind. Since the educationists and administrators have failed research students, the students should be encouraged to form their own groups. During our undergraduate studies, the greatest gift was that the Presidency College remained closed for much of the first half of our entire undergraduate studies. That helped us to branch out. We discussed a lot among ourselves, even tried our hand on research problems, which through were a naive choice of problems but we did learn a few things and had the confidence of handling problems.

But how to fashion such groups of interested students? Obviously on an internet platform. I do know some students communicate via different fora and chats, but that happens more often at PhD level. One needs such exposure, much earlier in their careers.

In Japan, I found senior students helping juniors in many ways. May be our PhD students can serve the science

students in a significant way by keeping a contact with their undergraduate institutions. Of course Institutions themselves need to play a role in fostering this interaction. That this is not so, is where the problem lies.

After writing this chapter, I realized that this reads more like a siren/alarm, arising from personal frustration. None the less, this is shared by most colleagues I discussed with. The frustration is against the static system that we continue to adhere to and seem unable to change. Anyway, it is at least better to share our thoughts and angst rather than suffer in silence.

22

Dr. Who and/or Professor Shanku – scientists have changed but has the popular perception?

In popular perception, scientists continue to occupy an image of serious, grumpy, humorless men or women, always working or thinking. In real world, scientists have changed almost entirely, for good or bad. In this chapter, we discuss this issue, with a sense of humor.

I was recently accused of being a person who lacks a sense of humour, termed as *Berasik* in Bengali. My fault was in refusing to go to see a popular Hindi movie in Mantri Mall at Bengaluru. The same person, in the same breath, told that most scientists are the same everywhere – serious, humour-less and grumpy, always thinking and working and worrying. They are unfit for the civilized world.

Even though I have heard these before, I got upset but then thought there must be a kernel of truth as such statements were aired repeatedly. I realized that most of the pictures of scientists in books and internet portray a serious, often bearded man, as if there is a competition who can look more serious.

In a number of TV show characters like Dr. Who, and stories like Satyajit Ray's science fiction character, Professor Sheanku, the adorable scientist-professor appears as a crazy character and certainly unsocial.

But in the real world the scientists I see around me are different. There is no gentleman under the elms, symptom anymore. What we see is a group of professionals who are focused, calculative but without any benign neglect of material life.

The fun and humour has slowly evaporated and the dichotomy persists. I saw in the YouTube, a few lectures of courses given in famous universities by acclaimed scientists. Professors mostly looked serious, almost in pain. In my own lectures I looked equally grim, as if a lot in the world, depended on what I was going to lecture upon (while exactly the opposite was true!).

Personally, I found, that the mathematicians are the "worst" in their demeanour. Physicists also look pretty grim. Einstein was an exception as he often smiled through his beard.

Among the chemists however I found many excellent speakers who are also entertainers, like Dick Zare, Jean-Marie Lehn. Their lectures that I was lucky to hear were full of humour. Close to home, Bharat Ratna Professor C.N.R. Rao, has always been full of humour and laughter. I remember a trip with him along with many other scientists to the Konarak Sun Temple. He kept the whole group entertained with his great sense of humour and we had good laughs.

At this juncture, let me point out that poet Rabindranath wrote a great short poem where he asserted that he would never get very old to the extent that he would look down upon jokes and laughter and stop being merry.

On the whole, the label of the grim and serious image of scientist is embedded in the minds of the society. At a deeper level the scientists certainly complain a lot. In the past scientists were questioned and harassed for their propositions from the very beginning. for all times; Galileo

and Copernicus faced numerous difficulties. And many during the Second World War were made to suffer. But of late, a different kind of harassment has begun. I am not sure if this is, deserved or undeserved. (The latest reason one feels harassed is the pressure of success with applications for research grants. These are the source of endless pain and tension. Secondly, the scientists have become managers, travelling and attending meetings constantly. It is difficult to imagine as to how can one be too happy being a manager instead of being a scientist. Solving problems, thinking about them and writing about them, is so much more fun.

Then there is a pressure of prizes and the fellowships of academies. These are real, not just because of the prestige they carry but often your promotion and salary and additional remunerations are tied to these. All these perhaps make a scientist grumpier these days!

At the end of the day, we shall always have Feynman for us and to show to the rest of the world. I hardly saw a picture of him where he was not smiling. One just feels happy looking at him. He told us to have fun doing science. Actually you can do good science only when you are having fun with your ideas.

23

Students, students everywhere, not a job to be seen

Even thirty years ago, jobs were scarce. In recent times, the number of research students has increased many-folds but not the number of jobs in the market. What should a student do in such a situation? How does one navigate through the job market?

The scarcity of jobs is a serious problem everywhere and in every sphere of life but our concern here will focus on the PhD students who are facing a difficult time to get settled. I have no real solution to offer but I always feel that we should discuss these issues to keep their problem in focus of the society and together, may be able to make some progress. We can certainly increase the quality and transparency in hiring to ensure that the best gets the job.

During my post-doctoral days at University of Chicago we heard horror stories that one hundred people applied for one faculty position at a major university. Among post-doctoral candidates in the large theory group at the James Franck Institute, only a couple managed to get faculty positions during my tenure of two and half years there (1981-1983, to stress how ancient I am!). But the rest managed to get some positions or other. A few Indian colleagues returned to places like TIFR, IISc, JNU, etc. In the early 80's, the situation, was bad in the USA but okay in India.

Compared to now, the period 1980-2010 was really a golden period for Indian Science. In the past decade, I no longer know much about the situation in the USA or other

countries, but in India it has decidedly turned from bad to worse and has assumed scary dimensions. We see many of our ex-PhD students returning from abroad without any job, and are on their a 3rd or 4th post doc. This is sad, to say the least.

The reasons for the current stagnation/stalemate in India is well known, but still let me recapitulate. We produce far more PhD's than we can absorb with the present set up where most of our PhDs look for a faculty position (as their first choice) at IITs and IISERs. Neither does our Industry present an acceptable alternative nor do they offer jobs to PhD students. Industry is mostly happy to employ engineers.

Our state universities and junior colleges, although large in numbers, are not usually open to outsiders. In fact, a large number of PhDs who would like to remain in academia in a respectable position can be absorbed in state universities and colleges. But things here have remained opaque. Although, some progress seems to have been made in this direction but this has not been uniform.

Please note that I mentioned respectability. I know that private colleges offer lower salaries to their teachers and often the working conditions are humiliating. Local petty politics makes the lives of our young scientists unacceptable.

One often hears talks about protectionism (as discussed in the G-20 summit). One can understand this issue in the context of academia where we often refer to it as politics. Stated plainly, this means that the best candidate is denied a job because of local reasons (i.e. the vested interests). This is all too prevalent.

In institutions, when the reasons for different selections in hiring are openly discussed at the departmental and Institute level, there is hope for justice. But when the

selection process is determined by one or two people for their own interests, good candidates have little chance. I have seen this happen frequently to state that this is a serious issue. But again this is not discussed openly and we quench our anxieties through low key dissents over teas and coffees. This will not suffice. Industry and state universities and junior colleges need to absorb a majority of the PhDs in a country like India. The IITs and IISERs are getting saturated.

At the same time, there are exceptions and a silver lining. I recently visited an NIT which has recently hired a large number of faculty members in physics and chemistry on its way to build decent science departments. The hiring was done impartially and the new faculty looked impressive and enthusiastic. I came back with a positive feeling. In this particular case, both the Director and the Head of the respective department played a positive role. Thus, it is not impossible to get started and build a decent unit or department in state universities, and colleges. There is a need to avoid petty politics. And there is a way to enforce transparency in the selection process and it seems some progress towards this has been made.

There is a need for the creation of a job portal for teachers/professors/scientists where all the job openings would be listed. Usually, these are available in websites of individual departments but a common site can be really useful. Here all the possible openings from academia and industry should be listed including those from the state universities and local colleges. In fact, this should be made mandatory. This can go a long way in improving transparency in the selection process.

The situation in India is different from developed countries. Here the, soon-to-retire senior scientist should proactively work towards making this process more open. And, there

should be more dialogue and discussion on this important aspect relating to future of science and scientists in India.

One issue we never discuss is the parochial attitude that is all pervasive in India. Although one country, we hardly see people from other states getting jobs in state universities and colleges. It is ironic that we complain against protectionism in the international arena when we have so much protectionism in every sphere here in our own country.

24

"Searching for that one magnificent gesture that shall live for eternity"

This chapter is a result of several discussions I had with young folks during a "Theoretical Chemistry Symposium at Hyderabad (TCS-2016)." I was repeatedly asked to comment on the works of these young theoreticians, often by themselves, keen to know the merits and standards of their own work. I hope the following chapter helps them and other researchers, as my points are quite general. Good luck.

In a French movie that I once saw, a celebrated New York based black male ballet dancer was rumoured to be hiding in Paris. On hearing this, a young female freelance journalist set out to find him and the reason for his hiding. After a few failed attempts, she manages to locate him and even extract an interview with the famous dancer. She asked him pointedly the reason for his hiding in Paris which she found surprising given that, he was already so accomplished, so famous and so admired. In the beginning she did not get any response, but after some prodding, the answer came. The answer was something that I always remembered: *"I am searching for that one magnificent gesture that shall live for eternity".* The statement immediately reminded me of the "Swan" or "The Dragonfly" posture of the great Russian dancer (ballerina) Anna Pavlova that I have seen on many posters and calendars, and are etched permanently in my memory.

I was again reminded of this statement in recent interactions with many young theoreticians including my own ex-students during the "Theoretical Chemistry Conference, TCS-2016" held at Hyderabad, India. The students and young theoreticians came to me for discussions and also for advice and suggestions on their own work. In the course of the discussions, a few works of Peter Wolynes (protein folding), David Chandler (surface tension and hydrophobic effect), and Casey Hynes (water dynamics) arose repeatedly. I would like to remind the reader that this was a theoretical chemistry conference and I was approached mostly by students who we working on problems in Statistical Mechanics.

Later in the conference, I was talking with two other young researchers about the merit of their work. I told them that while many researchers are publishing papers in reputed journals, including some high impact ones, we are not making that kind of contributions that may last for 40-50 years, if not for eternity, and that other people would talk and discuss about them in the manner one discusses the contributions of Wolynes, Chandler and Hynes. I, then told them about the above story of the male black dancer from New York who was hiding in Paris **in search of that one magnificent gesture.** It is very hard to do such an elevated level work. Not only one needs to know a lot, be creative but also need to be aware of all the experimental and theoretical work, past and present, and be bold.

I am not going to discuss inherent or intrinsic abilities as we have no control over them. I am also not interested in students who are not willing or capable of doing hard work needed for such fundamental contributions. *I am only concerned with those young people who are capable of reaching great heights, but do not feel sufficiently motivated or have their enthusiasm and motivation dissipated in the middle of details and*

routine work. I am particularly concerned about those young faculty members who now have a job and can attempt to work of highest quality and in the process, one day reach the greater heights in scientific research. *The story about the dancer serves to illustrate the fact that one would need to abandon or reduce routine work in search of good, unusual and even unknown problems.* It is really worth pondering about how a few scientists seem to hit the jackpot of science again and again and again.

All my best wishes for the few, very very few, who shall no doubt attempt to achieve excellence! I wish them courage, isolation, imagination and luck buttressed by lots of confidence.

25

How to choose a good thesis adviser?

Selecting a thesis advisor is probably the most important decision in a PhD student's academic life. Even students do not know or understand how important this decision was going to be until much later in Doctorate career. In this chapter, some suggestions and advices are offered from my personal experiences.

Professors seem to know what to look for in a potentially good student. Frankly, I do not, as all my students chose me. But many of the Indian professors are really talented in selecting students. They go about this task with a single mindedness neither known nor anticipated by the new incoming, and often naive, students.

The above apparently disjointed statements are related as they lead to the same question: How does a new/ inexperienced student select his/her PhD thesis adviser? Given that this is going to be one of the most important decisions in a students career, how to go about this choice systematically so as to minimize chances of obvious errors, in the least?

Without too much ado, let me start on possible strategies to adopt. I shall write as if I am talking directly to the students.

1. The very first advice: You should not restrict yourself to a preconceived subject area. This is a huge mistake often made by the student. Be flexible. Have 3-4 areas in

mind. Be ready to change. *But know thyself.* By that I mean that you need not move too much away from your areas of passion. If you like quantum chemistry, do not go to a group of organic synthesis. You may do theoretical organic chemistry through which has a big component of quantum chemistry. These are just examples to drive home the point.

2. Often students choose to work with an adviser they have already communicated with. Do have several communications and read the responses (if at all received) carefully. There is nothing like an on-site survey. Students in many western universities make additional trips to departments before joining a group.

   Students must keep in mind that they know little about the vast area called research. By selecting a guide without much interaction can be fatal. Often a student seeks a guide based on the recommendation of his/her undergraduate teacher. Also, liking for a subject develops under the influence of a good teacher. These are good influences. There could also be bad experiences that play important role in the formative years. Let me chronicle a short story.

   In a cold Christmas vacation in Madison, Wisconsin, I went to the department to pick-up a few notes. On the way down in the elevator of the chemistry department, I met five Indian students who came to Madison to visit friends. They were from different parts of the US. They were all ex-IIT students. I asked them their area of research. None of them were doing physical chemistry. When asked them the reason they all said that this was due to their teachers. And, it seemed all had "bad" physical chemistry teachers who scared them away.

3. When you are about to join a department, *make sure to inquire your freedom of choice.* Often students are assigned to professors internally, without students' explicit

knowledge. Of course professors take into account of students' stated interest in the interview or obtained via communication. Do not forget to ask whether you can have a choice after joining. **This is where certain amount of research about possible guides should be done before the interview.** I have told this repeatedly. I find this appalling in these days of readily available information via internet etc., students happily come to interview without any homework about the faculty. Note that at this stage of life, one is not young any more. Do not expect others to decide everything for you. In the Indian system, this can create an insurmountable difficulty. You are often not allowed to change after you join. Actually, there needs to be a movement to make the student-adviser relation more democratic and free, and not a slave-boss relation. Students should be allowed to work with whomsoever they choose to. After all, the government is paying the scholarship and salary! One always hopes for a balanced, mild tempered PhD thesis adviser, but such expectation might not be satisfied all the time.

Do not be afraid if a professor or guide has a reputation of a bad temper – I am not talking of myself. Many of the best scientists have a caustic tongue or low level of tolerance for mediocrity. But often these people are very good and better than sweet tongued, friendly guides who could be useless. On the door of Wolfgang Pauli, students placed a board stating: "beware – he bites" (from Victor Weisskopf's autobiographical book on life in physics). My mentor Bob Zwanzig was famous for his intolerance for mediocrity. Actually, all my teachers (David Oxtoby, Stuart Rice, Graham Fleming were all scathing in their criticism of mistakes but that's how we learned to do science). So, do not be afraid. But at the same time be prepared for some amount of bashing! *Actually, you should be wary of the guides*

who are too smooth and polite. Scientists who love their work can sometimes (not always) be rough and impatient.

Find out if your future adviser stays in the laboratory at least for a certain amount of time. Long distance supervision does not work. These days this has become a serious issue that is not discussed as much as it should be, with many committees and meetings. Some professors do manage to balance everything but usually science and the training of the student suffers.

Students of a given group are always a good source to find out about the situation. Talk with them before you decide. That is, take as much care as possible and try to take your destiny in your own hands. We do not know the future but you can try to make the next 4-6 years that you are going to spend in a research group, enjoyable. **I wish you the same. Good luck and bon voyage!**

26

Smart talking does not necessarily mean smart thinking or a smart mind

A student should be able to differentiate between projected smartness and real smartness. Most often, smart talkers are not good scientists, as explained here with examples, to teach students how to differentiate.

When I was a student in Uttarpara Government High School, in the suburb of Calcutta, we had a couple of friends in our class who were remarkable for their quick wit and smart talk. Unfortunately, however, the latter was mostly used to put people down, laced with sarcasm which at times was vicious. The name of one such friend was Pankaj which literally means lotus flower. He was otherwise an average student and also was not terribly good at anything in particular. I still vividly remember (after 48 years) an evening I spent with him, walking back and forth on Bally Vivekananda Bridge (over my ever favourite river Ganges).

I remember how much fun he made of every comment or observation I made or tried to make. We were teen aged boys and the weather was great and we had a great view of the River Ganges flowing below in all her majestic glory. There were a few other groups walking, even some girls. Try to imagine the scene – And I used to be quite happy that time, but not that evening. I realized even then and more so later that Pankaj often preferred small audience to unleash

his "talent". Somehow in a large gathering of friends, he was quiet. As I already mentioned, he was otherwise not remarkable. But he always made people very unhappy. Later I realized he was just a bully, a sadist. I do not know what happened to him. I never met him afterwards, and also never heard of him. He just dropped out of the scene.

Another common feature I found among all these smart talkers was that they were in many respects non-performers but always had a high opinion of themselves. Probably this high opinion combined with a lack of inner self-worth lead them to behave in this way. I think this forms a vicious circle because these people base their high self-opinion because of their smart talks/comments which often derived sharp reaction, laughter, even admiration sometimes, which these people enjoyed. This leads to a misplaced self-belief, that they were smarter than others.

I often used to spend my late afternoons on the bridge walking as my father always forced me out of home (Ï shall slap you if I ever find you home in the late afternoon) as soon he returned home (around 4:30 PM or so). He disliked the so called goody students who spend their evenings with school books. Those were times when I suddenly tried to become studious (for a short period though).

Returning to the title of this chapter, such smart talkers are hardly smart people! I have not found a single smart talker to have done well, except in politics. In politics this could be a powerful weapon, particularly it helps insulting, humiliating a rival of the other party, to mock in a blistering fashion. But what is a fair play in political arena, stands out as odd and even harmful in the academic world. Unfortunately, these smart talkers often find support from mediocre people who often rally around such a person who is seen as a bully and intimidating. These weak people find a strange sense of protection in such a person.

Of course, "The strongest man is he who stands most alone." (Henrik Ibsen). But standing alone is no fun for anybody, and can be done for a certain period of time only. Fortunately, there not many of such bullies in the society, but one should recognize them from the beginning and deal with them accordingly. As one of my famous friends once taught me "Avoidance is the best policy with such people".

27

How to monitor/judge/build your expectations in research and avoid wrong steps

Is the new entrant to the Ph.D. program aware of the long road to the degree, the hard work involved and the end product after five years? Here we discuss that the students should learn early the merit of hard work and discipline.

Over the years, I have noticed that many students (not all) come to science research with wrong expectations. This is a serious issue and needs considerable thinking because **expectations are intimately connected with performance. We must respect our own expectations.**

Professor S. Chandrasekhar, the great astrophysicist made a poignant remark *(in the book "Chandra" by K.C. Wali)* on this topic of wrongful expectation that hindered research in Indian science in late nineteen thirties and forties. This was subsequent to the discoveries by Professor SN Bose and Sir CV Raman. These were again preceded by great discoveries by Sir JC Bose. The young physicists of India, were led to believe **that great discoveries could be achieved by mere thinking and did not always involve hard work.** All it needed was an inspiration to make a breakthrough! That great discoveries could happen spontaneously.

Professor Chandrasekhar learned the correct approach after reaching Cambridge University. It was good for science that **he learned early the merit of extreme hard work to**

achieve any tangible success in a worthwhile problem. He continued this extreme hard work all his life.

Again, just spending a lot of time in the laboratory does not mean hard work. The work has to be focused, deliberate, with a final objective that would, lead to the next step of the ladder. Let me again chronicle a really beautiful story.

When I was doing my post-doctoral work at the James Franck Institute (JFI) of the University of Chicago, I often stayed back all night at JFI. But typically I used to find a place to sleep from 5 AM onwards till the janitors came and woke me up around 7:30-8:00 AM. They were a friendly lot and always asked me "Man, don't you have a home or a wife or a girlfriend?"

Now, to avoid the janitors I found that the research institute (RI) library had a good place, somewhat free from intervention by janitors in the early hours. So, I started sleeping there. But a new trouble emerged. Every morning, around 7:30 AM, the door used to open gently and one person would silently come in and scan through the many journals. First few times, in my sleepy state I did not know who it was and being a bit irritated, ignored and continued sleeping. But once I got up and found to my horror the man was the Great Professor Chandrasekhar himself (YES! the same Chandrasekhar!), standing there in front of the rack of new journals, reading. He smiled gently at me and continued his reading. The benign indifference was evident. But how could you sleep like an idle student in front of the great man? So, I lost a good sleeping place! But till to date I remember his face. Then I thought he would have been thinking "what a lazy boy". But now I deciphered his benign smile - "the young man must have worked all night, and it was too late to go home".

But the main merit of this episode in this personal story is that even at 70 or so, Professor Chandrasekhar used to

come to the RI library at 7:30 AM, scan through journals and read them quietly before anybody come to the library. The moral of this is that serious and successful people tend to evolve a working framework that allows them to work most efficiently without seeking special arrangements.

Back to the topic of this chapter, I see a malaise of a different kind in (Indian) science today. As always, I address the students directly.

a) In the absence of any exposure to research during undergraduate studies, students come to us without any clue about the research process. Since in India the undergraduate study takes five years which is an awfully long time, it is a huge loss, as they learn very little on critical thinking. For example, only a few students who come to us could write computer programmes or work with Matlab or Mathematica. In experimental research I would imagine this translates to spectroscopic measurements, NMR, vacuum chamber etc. Students need to develop some idea themselves by reading journals which are available online – at least some are free. Even in the best places, like the IITs, research exposure is limited.

b) We have almost no summer schools for our students. This is a must to bridge the gap between class room studies and actual research. So, students cannot even build expectations and/or aspirations.

c) On top of this, many students expect that publications shall come fast and easy, and that every new result is publishable. This is not correct. Students are often guided by seniors who themselves may not know anything. First few years one should focus on learning and developing skill relevant to research. And, there are a many, many things to learn.

d) The last expectation stems from students' lack of awareness that they need to repeat experiments and/or calculations to check the accuracy and reproducibility.

I blame the above wrongful expectations on our recent modifications in the examination system. **In particular, to the practice of giving part marks to an attempted question where the final answer is wrong**. This is particularly bad in mathematics and physics and, also chemistry where the final answer is the most important. By giving a generous partial mark to a wrong final answer sends wrong message, a powerful negative signal, that it is okay to be wrong. I see this mental attitude in students a lot these days. They are careless about mistakes.

This expectation is coupled with another related one. **"If I make a mistake, my guide shall find it. It is his/her responsibility".** Students should know it is his/her responsibility to find his/her own mistakes. Nobody likes to and can ever clean others linen.

Here I would tell the story of the transformation of bandit Ratnakar into Maharishi (great saint) Valmiki. In this story, no body (neither his parents, wife nor children) agreed to share Ratnakar's sin. Similarly, in **science you won't be able to blame anybody for your mistakes, or share the responsibility of your mistakes. It is solely your own responsibility.**

e) There is also an expectation that the guide/supervisor shall suggest new problems, find and correct the mistake, tell how to write the paper. This can happen to a PhD student starting his work but not for an advanced student who is expected to find his/her own problem. Actually best work often comes out from a group when the students search for new problems and take a few initial steps to examine its feasibility, before bringing to the guide's attention.

f) It is a common and absolutely **wrong expectation that** *proper and good* **English writing is NOT important in science.** This has led to one of the worst scenario among science and engineering students, and at times ruined the research career of a large number of students. This is particularly acute among Indian students, for reasons not clear to me. As a rule, while students spend considerable time and effort to master mathematics and science, they spend little or no effort towards developing their communication skills including writing clearly in English.

Note that both the SAT and the general GRE exams give equal weight to English and mathematics. And, they test nothing else. Just two examinations to find out about the students. In many countries students start preparing project reports even from 5th grade, which provides a good learning experience. This is done in some schools in India, but with a misplaced and ethically injurious encouragement to copy it from Wikipedia or like.

g) The expectation that "only have to do as told by the guide to get a PhD" has a disastrous consequence. I increasingly find students have no clue to research even after couple of years. This becomes clear especially after their third year because in the first two years they get help from seniors and then they tend to hide their ignorance.

In research, one's own initiative allows more progress than the ones that come from your guide/adviser. You must think, think and think!!

I know that sometimes advisers themselves do not encourage independent thinking. But think one must. If necessary, hide it from others that you are thinking. Many people did that in the past. Nothing new. A thinking man is known to suffer at the hand of mediocre.

The bottom line is as follows. You need to remain conscious of your research aspirations, judge them, monitor them and try to evolve. It must also be realized that it is one's duty to evaluate his spending five years of his prime life and ensure that every second of it is gainfully used for learning.

Again, bon voyage!

28

Reading and writing (or, writing and reading) and the visual medium: Teaching must quickly change in our schools and colleges

Teaching has changed in recent years and will be increasingly dependent on online teaching with use of visual medium.

During one of my leisure evenings, I watched two documentaries on Rabindranath Tagore – one by Satyajit Ray and the other by Rituporno Ghosh. Both were outstanding film directors, at different times – the former being widely known and is a house hold name in movie circles across the world and Rituporno has been enormously talented, liked and admired.

While watching the two documentaries in succession, I realize the tremendous scope of visual medium. This may appear funny to most of you because you already know it, but please note that I was (and still mostly am) always for books, printed on pages, although recently I am given to read from laptop and i-pad because of the ease of storage and also for reading during nights with falling eye sights.

What I want to stress is that the impact of these two short documentaries was remarkable. They make the tumultuous (& torturous) days of British India vivid, with a good exposure to the history of our freedom movement. **At the**

hand of the two masters, the period (1870-1940) comes alive with all its social, cultural and historical attributes, the freedom movement with euphoric patriotism and nationalism that even swept Rabindranath away. This is an important point because in later years Rabindranath kind of turned away from nationalism as he realized the merits of an international approach.

These two documentaries should be shown in every Indian School. May be in the 7th or 8th grade. That is the right age, the formative period and impressionable age. **These movies can educate the students like no book can ever do.**

I consider that such documetaries could be the way much of history, geography and social sciences can be taught. For geography, numerous documentaries exist and more can be made. The same may not be true for history, particularly, the Indian history. But documentaries can be made, region wise and time wise. It can be a wonderful and an effective way to teach students between the 5th and 10th grade.

In most places, these interesting and important subjects are taught boringly in most schools. A few parents told me that in some good schools this approach suggested above has started. But I am afraid that the slides and pictures again shall lead to a deluge of information. Actually, too much information is not required — we need more pictures, with a connective narrative and an interested student can then explore further. We need the young students to feel the time and the contemporary emotions and the narratives of the freedom movement.

In the next step of education, we can ask students to write his impression on the movie. This can allow each student to express in his/her unique way. They should be encouraged to speak and debate. Most of our PhD students learn to speak intelligently after joining the graduate course. The process should start earlier, much earlier.

I once asked my friend and colleague Professor Graham Fleming (an outstanding scientist and, then the Vice-Chancellor, University of California – Berkeley) how do all the British scientists speak so well. He told me that they learn the art of presentation at the school. He told me that the same happens in France and many other European countries.

Combination of visual medium with speaking and writing, makes it an enjoyable and educational experience for all. It is likely that suddenly the students usually marked as poor students, start outperforming other brighter students. One needs to ignite minds, passion and enthusiasm of a young student.

What I am proposing is that during early education, formal reading can be effectively combined with such aids. Visual medium is a great substitute for reading, but not for writing and therefore empahsis on writing skills should be kept in focus. It is time appropriate to refine the age-old paradigm teaching with 3Rs.

Of course some people shall continue on the reading path on to the great classics of our and foreign literature, but for most purposes, including creative ones, writing and visual medium can be used effectively to make the instructions effective.

It is arguable that to a large extent, reading study books has outlived its utility. Majority of the population may not read other than a few basic things. Visual medium shall take over and nothing can be better for young students.

29

Is there a genuine case for publishing in Indian science journals?

We return to an old subject that has seen endless debate. It is sad that a large country like India does not have widely known successful journals. A journal can help shape the science of a country in more than one ways.

This has been a topic of intense discussion between the past Presidents of Indian science academics and the science administrators. But working scientists, by and large have ignored their constructive advice to publish in Indian journals. To a large extent, we all are a party to this neglect of Indian journals. However, Indian journals have survived and some are actually performing well. A few of papers from our group that were published in Indian journals, have been cited well.

Science is international. But science publication is not. Regional biases do exist. It is significantly easier if you have a western address. And, one shall have additional difficulty if those are doing well and competing internationally. Though it may be discipline dependent, in the author's experience in chemistry and biology, the publication process tends to be more parochial.

Nobel Laureate Professor Ahmed Zewail, once told me a great sentence, when talking about a colleague of mine. He told that "All you need to do is to scratch a few times to find the true colour of the skin". It was meant to be understood

in a metaphorical sense, not verbatim (that is, not as a usual naming assigned to the colour of skin etc.)

It is clearly a question of our mind set. We evaluate our scientists by the impact factor of the journals that he/she publishes in. Of course, the impact factors go up and down, and also depends on subjects. Even an outstanding work on mathematical physics might get cited only 10 times (but figures in text books), while any average work in nanomaterials or graphene can fetch hundreds of citations. We have seen such things happen during high temperature superconductors when many papers got cited many times, but most were completely forgotten and disappeared without a trace.

Thus, both the impact factor of a journal and citation number, h-index etc. are not good measures on the quality of any contributions. It however does help us getting a picture of long term activity of a scientist.

Prof. CV Raman used to employ an interesting approach. He often published the initial work in the Indian Journal of Physics (IJP, used to be published from IACS, Calcutta), to be followed by an article in Nature.

At the core of all these ramblings lies the fact that International science is fiercely competitive. It probably always was but now this is reflected in our attempt to publish in foreign journals. This is especially so in established fields.

Why is it so? Let us analyse this a bit. In areas of publications in Science, India is increasingly being considered as an advanced country. So, we pose a threat. Second, there is some racism at work here and we cannot deny it. And this happens and happens at not too subtle a level.

Let me recount my experiences. When me and Amalendu Chandra put forward, our papers on solvation dynamics, they were criticized, particularly after they became popular.

However, the same authors never went back and retracted their criticism when it was proved that we were right and they were wrong. At some stage we did find it difficult to publish our papers.

More recently, the same is happening with our work on biological water. But fortunately we have published papers. The students suffer the most when their papers are withheld. So, it is a mix of racism (in a more sophisticated and subtle manner than the usual) and also the resistance from competition from the colleagues that arises from a perceived threat to credit and contribution.

I think Prof. CV Raman's approach was the best. Publish first in our own journals. The advantage is manifold. We can argue with our own Editors as is done by Western authors with editors of front-line journals.

So, my recommendation to Indian authors is to publish in Indian journals, at least partly. And, donot glorify publications in a front line journal. What really matters is that the peers **should know and respect the work, not the newspapers and public. Even now, a good work is a good work — irrespective of journals! Good journals only give you a short term gain. Of course, if the work is not good, then that gain is the only gain you shall ever get!**

But we need to become more responsible and benign to each other and not behave like a "nation of crabs" that we are famous for. We need to be fair, objective and respectful to others during our evaluations. **Internationally, we need to argue from a position of strength — not from a position of weakness due to greed and self-glorification. A good journal is essential. India is a big country we cannot and should not for ever depend on foreign journals. They will remain foreign, for ever.**

30

Why so many good students fail or falter at a later stage? And what could be the remedy?

Here we explore a question outlined in the title. Many students succeed in early stages but falter later. The reasons are detailed and some remedy offered.

This question has always intrigued me. Why some students who do well in the early part of their academic life, falter late in their research life and beyond? At the PhD level, achievement index has certainly come down. Additionally, I find that many Indian students with PhD from Indian universities do not perform well in their post-doctoral work abroad. Maybe it is too early to comment on young faculty but some are indeed performing well.

Back to students. Many of our students are studious and serious. Then where are the lacunae? I do not subscribe to the logic that all good and meritorious students leave for engineering. We all know that clearing the entrance examination needs very hard work, and certain intelligence, but not too much of it. I always feel happy when I remember that my father did not allow me to even pick up the forms from Kharagpur IIT or Shibpur Engineering College when my friends were doing the same. He just told me go to the Presidency College. This was a tall order in those days because 6 of the top 10 state students and 10 of top 20 joined Presidency College in our year. That was a long time ago. We were willing to stay starved and go naked but

determined that we shall not leave academics. This was a quote from a friend in the Coffee House! (I did not like the use of naked though!).

Anyway, let us get back to the failure of the young PhD or post doc students. What is the reason? Let me first give my answer candidly, and then elaborate. **The main reason of the failure is not laziness or stupidity, but a misplaced expectation that gets cultivated in the early part of life, in respect of both the scope and the difficulty that one would/could face when they climb up the ladder in a research career. Sometimes the expectation is misguided.**

Research is like climbing a mountain. Only those who have an understanding of the difficulty, succeed in climbing higher mountains. Also, to climb a big mountain you need to climb many small mountains. The main point is that one can indeed climb high at any time but needs the three Ps of Passion, Practice and Patience.

The successful workers always try to improve and succeed. One finds them always climbing small mountains and they never sit idle. Where does this low estimate or expectation begin? Usually pretty early, may be within the first 10 years of life or so. May be early success or wrong message from parents and teachers.

Teachers play a particularly important role. A good teacher can launch many students to successful research careers. But it is difficult to get a good teacher who can motivate students, and at the same time point them towards the right direction. I would guess that a large number of students work without a good and inspiring teacher.

Let us factor that in. Let us also accept that in certain sense, it is a failure of the system. Our society is failing to build up academic aspirations but is doing well in this on the monetary and materialistic side. We might be producing executives but not scientists, writers and thinkers. These of

course are difficult. But science is not that difficult as there are systems in place.

Generally, engineering students have a poor opinion of science students. This reflects the general belief that science students are not good enough to do engineering. But often the reverse is true. In the developed countries like USA where only a few opt for engineering as it is perceived as boring and tedious.

It needs to get ingrained in student's mind **that improvement is a continuous process,** till the end of one's life. The same student might be working quite hard in other spheres, like sports or drama. Robert Zwanzig always used to say **that a serious student must learn as many techniques and develop as many skills as possible**. This is applicable to both theoreticians and experimentalists. The details of course differ. The main point behind Robert Zwanzig's advice is that a student needs to self-train. One must prepare for success. **Self-training is a big component of PhD**. One should not always wait for their thesis adviser to suggest or recommend papers, techniques. One must find out his own and in this internet if used constructively, will help.

Other factors include, absence of good and inspiring scientists in major universities; poor training in schools and colleges; loss of good students to engineering streams. But I do not believe they are the root causes. Five-six years that a student spends in a research lab is long. I know many scientists who did extremely well after going to schools that hardly trained them. A PhD program provides a student a lot of room and time to develop and all that is needed is a passion to learn and and innate urge to succeed.

But at the end of the day a student should know where they need to go, as also that they can go very far. It is also a fact of life that all will not, or cannot succeed. But the percentage

of failure after one joins a PhD programme is less than 30-40%. That is, most can be successful at some level.

But remember the analogy of climbing mountains. One must climb all through one's life many small mountains in order to climb a high one, may be once or twice in a lifetime. But that would be enough.

When Linus Pauling was asked how he obtained so many great ideas, he answered that key to get a great idea was to get many ideas. **For this, a student must have a high expectation of himself, and a good estimate of the difficulties ahead.** This combination of high expectation and good appreciation of the difficulties is essential to propel a student to work hard and achieve.

31

Professor Mihir Chowdhury is no more

Here the author remembers a successful famous teacher with the aim to understand what makes a teacher great.

Our beloved teacher Professor Mihir Chowdhury passed away in the evening of 28th March, 2017. He was born in 1937. Professor Chowdhury left behind a legacy that is difficult to match. Not only was he highly respected for research in experimental physical chemistry but that he produced and mentored many outstanding students who currently occupy faculty positions across many institutions of India.

Professor Chowdhury can be rightfully considered as the architect of Laser Chemistry in India. His impact on the national and international scene in this area can be seen from his students and students' students who are carrying out research in frontier areas of chemical dynamics, and are internationally well-known. He truly established a school, which is the most difficult thing to do.

In addition to being an almost perfect PhD thesis adviser, Professor Chowdhury was also a great teacher in the class room and outside. He taught for many years in the chemistry department of Presidency College where he used to teach also the MSc students of the Calcutta University. He taught us in four of the five years that we studied at Presidency College during BSc and Calcutta University during MSc days. He taught us undergraduate physical

chemistry for two years and then later Quantum Mechanics in the first year and Group Theory in the second year MSc. He was outstanding in every sphere but we all remember his great mastery of quantum mechanics and group theory.

There are many anecdotes and happy memories to share and chronicle. In 1970 when we joined the Presidency College, the college was under siege by the extremists. He was heckled and harassed by this group of people, and he could not come to college for almost a year. A young professor who substituted for him in the first year undergraduate class started by saying "you students are unfortunate to miss out on the initial lectures of a great teacher and an outstanding scientist. I am no match for the great teacher. And I hope he will soon return to take his position that I am temporarily trying to fill."

That was quite something for us! From then on, we looked forward to Professor Chowdhury's return which happened only in the month of May, 1971. Interestingly, he did not spend time on what was done on Thermodynamics during his absence, but started to teach the whole subject from the scratch. And we soon realized why was he respected so much and regarded as a great teacher, and what a great teacher could in communicating the nuances of a subject.

I still remember a few words that he repeated a few times. "Thermodynamics is based on laws of negation. If you could find one counter-example, the whole temple of Thermodynamics will come crumbling down". I will remember this forever. He was always articulate.

He used to enter the class slowly, always impeccably dressed. He would first pick up a full white chalk, slowly break it into two pieces, and then walk even more slowly towards the window (on his left when facing us), and stare out for a moment (that one of my friends described as "looking into infinity"), slowly turn towards us, and

started speaking "In the last class, we discussed …..". The effect was spell-bound. We were all attentively glued to the lecture by the master.

Another interesting comment he made during his derivation of quantum mechanical expressions for hydrogen molecule we remembered forever "to be a physical chemist you need the genius of Emil Fischer and patience of an ass".

He was ever so encouraging. He played a big role in my academic life through an episode I chronicle now. One day I came to college early — as I had to take a train from my home at suburban Bally to Sealdah Junction and trains were only once in couple of hours. Our class was in the new Chemistry building (now on top of Derozio Hall). I was walking idly along the corridor and came to the end where Professor Chowdhury's office with a small Lab on magnetism was located. I was a bit absent minded, pacing back and forth along the corridor, waiting for my friends to appear. But after seeing me hovering over there, Professor Chowdhury (we always used to refer to him as "Sir" — actually the only Professor we used that title when talking among ourselves) came out, in his usual slow pace. He asked me "Biman: are you looking for me? Do you want to ask something?" He was then teaching us Quantum Mechanics. I was a bit terrified and nervous, and seeing his expectant look, I thought I must ask something. So, I took out a notebook where I was writing some derivations, and asked him a few questions. Not only did he answered them, but then followed up with the suggestion that I should finish the notebook and then give to him for correction.

Notes and derivations were largely from his lectures, but supplemented from my other readings. I was quite enthused. I liked writing from an early age. So, with full gusto I launched myself into preparing notes on Quantum Mechanics. When done after couple of weeks (as my faint memory tells me now), I went and gave it to him.

Sir took his time. But when he returned the notebook after two weeks, every page was read and corrected; every equation was clarified, even partly re-derived. I was so happy and energized I can still savour the feeling. Sir was already famous; he got his Bhatnagar Prize, was a Fellow of all the science academies of India, and therefore he was already established both nationally and internationally. In fact, he was offered faculty position at the University of Chicago and this was a great recognition in those days. But here he was, going through a fat notebook of a fairly ignorant student, line-by-line and correcting all the mistakes and improving concepts and derivations.

I know no other professor who would do that for an MSc student. I must emphasize he volunteered, encouraged me to prepare the notes and then corrected it all around. I always got high marks in quantum mechanics — not just at Calcutta University but also at Brown University and I gave the credit for this to happen to Sir, then and even now.

Much later, I found myself in almost the same situation. I then wrote an invited article in *Annual Reviews of Physical Chemistry* and I sent him a copy of the article. In my next visit to IACS, I found the article lying on his table. I picked it up and glanced through it. The pages were full of comments and questions, clearly written in pencil — the same way he corrected my quantum notes in 1975! He had several questions and he started asking me those. I sensed that he was less than satisfied with my answers. I left with the feeling that not much has changed between us — he would remain always the teacher trying to point out things to me, telling me to be logical.

Sir wanted me to join Indian Association for Cultivation of Science (IACS). After I received offer from several places, he wrote a long hand-written mail, clearly describing, point-by-point, advantages and disadvantages of various

Institutions. I think he was a bit hurt that I did not join IACS. But I do treasure his mail to date.

Another nice story comes to mind. During late 1992, we went to a DST meeting in Baroda and we were spending a night at Bombay. Somehow Sir and I found ourselves walking along the Marine Drive near the Victoria station. I was asking him many questions, about science and Indian science politics. I think after getting bored with my questions, he told me "Biman, what are those vendors selling". There was a couple of street-side vendors selling some juice and syrup and were shouting *Khatta-Meetha*, *Khatta-Meetha* meaning sour and sweet. However, Sir of course knew what they were selling. He recommended that we should go ahead and have some. I was a bit surprised as Sir was pretty strict in his habits. Anyway, we went ahead and had one glass each. He liked, and suggested to have a second one.

In the same night, there was a knock at my door around Mid-night. I opened the door and found Sir was standing in front of my door, looking a little pale. I asked "Sir, any problem?". He told me "Biman, do you have any medicine for indigestion?". I used to carry some which I gave to him. He went away.

I was a bit worried. It was clearly an effect of *Khatta-Meetha*, but how strong would be the effects was any body's guess. I already mentioned that he was not in the habit of straying from his rather strict code of life. He was okay the next morning.

He was ever so balanced a person. But that night at Bombay was the only time I saw Professor Chowdhury in a child-like form. He once told me that the fact which found admirable about Mr. Jyoti Basu (West Bengal's Chief Minister for 21 consecutive years) was that Mr. Basu was a balanced person. That also typified Sir's own persona.

In the midst of emotional outbursts and tantrums that characterize Calcuttans, Prof. Mihir Chowdhury stood out for his balanced reaction, his mildness and his kindness towards his students. He was a perfect gentleman.

If there is a heaven, I sincerely wish Professor Chowdhury, our beloved Sir, finds a peaceful place among balanced, sincere and honest people who do not shout unnecessarily and do not throw tantrums. Ever a gentleman, he disliked those.

May his soul rest in peace!

32

Play SAFE: Self-Appraisal, Flexibility and Engagement (SAFE)

The author discusses the role of self-appraisal and self-criticism as the methods to improve. However, these are demanding practices and require determination.

To be young is wonderful. But alas this does not last long. These days you need to achieve a lot in a short period of time. So the best time of your life is to be managed well. It is getting increasingly harder to achieve success that you want, often badly.

There is a great movie by name "The Wind Rises" by Japanese director Hayao Miyazaki. Please watch it if you can. There is a poignant comment made in the movie which says that one gets only ten years (mentioned as *your time in the Sun*) to achieve something great. One has to make full use of these ten years. This is of course, metaphorical, but the message is clear. We do not get eternity. This also points to many involvements in life that come with age.

The PhD and post doctoral years certainly come under "the time in the Sun". May be the initial years as independent Researcher (whether Assistant Professor or a scientist). These periods are extremely important for one's future and cannot and should not be wasted. One must make use of these times very judiciously.

I start with an example to illustrate what I mean. This is a story from my own life but I know several others can

tell similar ones. During my PhD, I was stuck with a fairly useless problem. However, there was no way to get out of it because my adviser would not listen to my arguments as to why this project was not going anywhere. It was a desperate situation. Frustrated, I started spending a lot of time learning different methods/techniques in different areas. I started interacting with two other faculty members, essentially to learn other things. Also started to spend a lot of time in the mathematics department, auditing advanced courses. My own research did not take too much time as it was not going anywhere. I was aware that things were not good, and that I was not fully to blame. But I stayed engaged in studying and learning new things.

Finally, I could team up with another graduate student and finish two projects that addressed different problems but used the same methodology my adviser was advocating. As the results were not bad, I could submit my PhD thesis and get out of a difficult situation.

After landing at the University of Chicago, I found that I was the one with least number of publications. It was very stressful. However, the subjects I learned outside my thesis work proved instrumental in my post-doctoral work. My post -doctoral adviser and other faculty members at the University of Chicago were really impressed as they did not expect me to do so many quite different problems. One of them wrote in my recommendation that "Biman was magical". There was no magic but I just knew a few things that others around me did not know. This is the reason I repeatedly tell my students and others to explore many avenues, learn as many techniques as possible.

Richard Feynman attributed his success to having a different bag of tools — things he learned early outside his curriculum but those others including his fellow scientists did not know. Of course he was a genius. Bob Zwanzig

always used to tell me that serious students must learn as many tricks of the trade as they can.

This is what I mean by resources. They are both outside and inside you, but one needs to be conscious about it. Sometimes you have to reach out for help. You might be rebuffed but that is okay. Take it in your stride. *Flexibility is the key.*

Sometimes success is just a meter away — may be on the other side of the main road. Much later, Professor Hegde of IISc, gave me an article "How to become great?" that advocated exactly the same method. Here the writer, a successful scientist wrote how spending one or two extra hours after everybody was gone from the laboratory helped him master many techniques and those extra hours later led to his success. It reminded one of the British footballer's life story. English football player Beckham used to stay one extra hour each day after the team practice to perfect his curved ball into the goal. This extra effort helped him and his team in so many matches.

But how to know or learn extra things? This is where one's internal resources come into effect. Also, it helps to be optimistic. It helps to mix with positive people. I repeatedly suggested that a student must avoid negative people - friends or seniors. There are a lot of them around and easy to get under their spell. It is easy to convince oneself that all efforts are futile. Luck determines everything. I propose a programme that can help students — I call it **"Play SAFE"**. It consists of three ingredients: **Self-appraisal, flexibility and engagement.**

(i) A student must regularly carry out an *appraisal of himself and of the situation***.** This is routinely done in many organizations, especially in NGOs. This allows you to find out systematically your own strengths and weaknesses, and progress. This opens a door for improvement.

The best way to do self-appraisal is to prepare a write-up. Take a note book and write down about yourself, your strengths and weaknesses. *Be brutally honest. You are doing it for yourself — you are important***.** If you have a good friend, discuss with them. Discuss with your adviser if you can.

My friends and classmates at Presidency College (Calcutta) once carried out such an exercise. Unfortunately, I was away that day. But they told me their appraisal of me. It was extremely useful. I still do not remember why they did it. But that was Presidency for you! It was really the best those days — amazingly versatile, bright and creative students. We hear so much about IITs and their penchant for making money but do not talk about great colleges like Presidency. What a shame!

(ii) Once you have done the appraisal, you need to reach out. This needs an important resource. You need to be *flexible* and less egoistic. Ego prevents you from reaching out for help. Flexibility in approach helps. You need to rectify your weaknesses and you shall need help. You would need to change.

(iii) *Engagement***.** This requires not just the hard work (a cliché — everybody tells you to work hard but you need to know how to work hard). Engagement with your work is essential. This in turn leads to success. If you are engaged, you shall automatically work hard. Sometimes this is called dedication but I like engagement better. The latter makes more practical sense.

Everybody should practice SAFE. It will really help!

33

How to learn a difficult new subject in higher studies?

In this chapter I explore the reasons for the difficulty that our students are increasingly facing in this ever expanding field of science and technology. I also discuss possible remedy.

Learning almost completely changes its nature in higher studies. In schools and colleges, one develops elementary skills that are based on memorization. Such memorization is essential when one is learning alphabets, numerals etc. The same applies to learning of a foreign language. Unfortunately, such learning comes with a heavy negative price tag. Our mind gets used to this method. Why negative? Because logical thinking takes a back-seat. In fact, the students who do better at this stage are often who have good memory and who are obedient.

We know the story of Einstein arguing with his history teacher. When confronted by his teacher for not studying history lesson, Einstein told that these are all available in books. So, why should one memorize at all?

In the Indian system, however, you would come last in exams if you take such an approach. However, all is not as bad as I might be making it to be. Often good students consciously or unconsciously find patterns and then use them to get over this stage without losing their reasoning ability. As mentioned, the nature and scope of education changes after the early teens. Here onwards, one starts with higher arithmetic and geometry. And, logical thinking

becomes important. You often find a few students who score poorly in lower classes and suddenly become good students. I have seen it happening many times. And also the reverse. First and second ranked students till the seventh grade suddenly become mediocre performers after tenth grade. In the Indian system, there is still too much emphasis on reading, much less on field-work and educational trips. Even writing homework is copying from books with little scope for development of original thinking and charting out one's own course. Even our late-bloomers carry some of the baggage of the early memorization-based training.

In higher learning, one may often need to learn completely new things by self with no body to guide. Often there would be no clear path. It is a lonely venture. One can be at a loss and miss the simplicity of memorization and simple well laid-out path. This leads to frustration and one wishes to abandon the academic journey.

In such a situation, one's own drive and resources are their biggest assets. But do they possess these assets? Or, that these are compromised through the current education system? I often see students are at a loss, making too slow a progress. Note that there can be no long lasting motivation if we do not understand subjects at some deeper level.

Why? Why is it so hard to learn and master a new subject? Most often the roots lie in one's past and in the current faulty, deeply faulty education system.

What I propose below is akin to detoxification in Naturotherapy or Naturopathy.

In detoxification it is forbidden to consume any toxic food, which,) include all foods that taste good. One is made to made to starve, drink lots of water and consume some awfully smelled food. This seems to help, although I have never tried it, but I know of some who tried, with good

effects. There is a close analogy. Many students love to read and read through internet. These may appear harmless but they can intoxicate minds. The counterpart would be to ask students to forget everything they have learned by memorization. But certainly that will not work.

What then is detoxification in Education? Obviously I have a prescription — otherwise I would not have started on this write up. The idea is to revive our latent ability to think that by memorization and routine studies attempted to kill.

i) My first prescription would be that students should not be allowed to read anything for a month or so. That is, I would form a group of students who shall be asked only to discuss and reason, and write. Writing is always a "good medicine" for intoxicated students. It is like an "in house" conference but for a longer duration. **You can write and talk but strictly no reading.** That is, you need to prepare a bit before you get onto a new subject.

ii) *Start with what one knows, but without books.* Students shall be taken to the limits of their memory. A good question would be asked derivations of formulae I would like to write "formulae" as plural, but MSOffice objects! that they did 3-5 years ago. They have to first reason and try to derive. They should not give up. Take oral help. Communicate.

iii) We do this in our oral examinations routinely. Most students try to remember which is evident from their expression and wide eyes. Very few try to logic it out. Some of them do progress by thinking after we give them a key and tell them that they have to go from there.

iv) *Go to the new subject only after you have thought about it.* The best way is to discuss, discuss and discuss. One must find a student to discuss with. I see that at IISc many students do that while walking, or at tea/coffee at the kiosk. Such students are on the right track.

v) Actually in the MBA and personality development courses, the emphasis comes back to talking, communication and writing. These are often good, effective courses. Practical.

One must start with what one knows. If one thinks he/she will discover that he/she already knows a few things. But starting straight with an easy path of looking at a book or the internet would be a losing option.

I find many students silently reading, and reading, and reading. This approach does not help. *At least one needs to write, make flow-charts, derive equations ….*

George Bernard Shaw famously said, "*Too much reading rots the mind"*. Too much movie watching or internet does the same. We additionally find that students who come through examinations by memorization and intensive studies have lost the independence of mind. They are to be told everything which is not desirable at all. But these students often think that the combination of "instruction and obedience" is the normal route to success. Nothing can be further from the truth in higher academics.

To detoxify, a student must discuss and write. That is the way to academic salvation. Next rule is that one needs to first think about the new subject, then discuss, and then launch into a book.

34

Why good behaviour and humility are your greatest weapons in this world
(not just in academia)

Humility is a must, unless you are exceptional. Need to be humble in communication.

Arrogance never helps — that we all know. One does not gain anything by looking down upon or insulting other people, however small or trivial they may seem. I argue that an overall, cultivated and directed good behaviour can do wonders to an academic career and even bring happiness. This is worth cultivating in the right earnest.

The Biggest damage is done by few instances of bad behaviour or emotional outbursts, particularly when directed at some body powerful or your boss. There is a great line of the poem by Sudhindranath Dutta, *"One moment of humanly weakness opened the door to my complete disaster"*.

People remember and are t**oo eager to remember one's failings** not their goodness. One insult is remembered for the entire lifetime. Thus even when one faces antagonism, arrogant or bad behaviour from others including colleagues, boss or friends it is prudent to keep *control, keep cool and be restrained. .*

People really remember bad behaviours. It is like permanent mark that no amount of subsequent good

behaviour shall erase. Such efforts will rarely be recognized or remembered.

This is not to suggest that forget bad or arrogant behaviours from others. We are not suggesting even for once that you forget the bad behaviour you might have faced. But try not to react. This is particularly true in India.

In the USA and France, I have seen that they allow certain latitude for bad behaviour if you have excellence. "A genius is eccentric." But this is not so in India. On the other hand, good and "sweet" behaviour is highly rewarded. People, shall hold you in high regard if you are pleasant and mild mannered. One of my senior colleagues once told me "It is okay to be arrogant but you cannot show it". A great piece of advice for any young, starting, a man in any profession, but forgotten most frequently in academics.

It is worth remembering that in India quality alone, sometimes does not count. That is why we rarely have merit based promotion, at least in public institutions. Most promotions are based on seniority. So one's destiny is fixed, the day he takes up job.

There is a well-known saying — Humility is the fine line separating arrogance and confidence. **And, I add a common saying: Humility forms the not-so-fine line between success and failure.**

35

What are the qualities that an adviser and a department look for in a PhD student, during interview?

This chapter provides insight from an interview room, with the perspectives of the faculty.

For a PhD interview, I thought it would help students if I listed the qualities we looked for in a student before we accepted them. Being a member of the selection committee, these could be regarded as coming from "horse's mouth". These are listed in a certain order of importance **and are possibly universal.**

i) The student should be interactive, with certain degree of quickness. **A sense of humour helps. Keep a smiling face and laugh with the rest even at bad jokes from the professors. This is liked.**

   More seriously, the departments are really afraid of inducting a zombie (a strange, willless, speechless person) in the group. The student needs to be a member of the community and help the group and the department. These days nobody is directly approached and asked for help but the students need to sense the need and volunteer service and help.

   Note that the department expects that a PhD student spends 20-25% of their time in helping group and department activities. Therefore, a potentially active and vibrant student is desirable.

ii) **Students should visit the department web page** and read about the faculty members. Though this effort is a must, it is surprising that how few students do this exercise. The committee is often surprised and disappointed when it finds a lack of interest in the students.

iii) Departments look for some independence but usually not a whole lot. This is really a tricky point as it runs counter to the point I stated above. So one needs to strike a balance.

Many professors do not encourage much independent thinking as they have fixed ideas on how to run their research programmes. Such an approach has both, positives and negatives. It is good to be in a group that is well run, disciplined and result oriented. But this may not suit a student who is independent, reads a lot, thinks a lot and is a freewheeling type. A good mix of all type of students and professors are needed in academics. Just as a student does not want a rigid and unbending professor, almost the same is true on the side of a supervisor, except that the power balance is different and the professor has the last say. But in cases of a good professor and a good student, such relationship can be genuinely rewarding. I had the opportunity of several such relationships.

But in an interview, one should not appear to be obstinate and inflexible. As I said, try to smile and agree when wrong. Try to be nice to the professor when asking questions and give him/her all the attention. Note that professors often have big ego (for God knows why?).

iv) **Do not be slow. This is really important. Do not be afraid. The outcome is not fully in your hand — there is a lot of uncertainty.**

v) The interview room is often a chaotic place. Most of the professors continue talking through the interview. It could be hard and even painful. But be prepared. Not

much can be done except keeping focus on the professor asking questions. They will continue talking and drinking tea/coffee.

vi) The professors are older than you, but unlike your father or uncle, not that forgiving. The relationship is different.

When I was doing my PhD with Julian Gibbs (and this happened also with Stuart Rice at the University of California), I often saw signatures of my father in them. This should be avoided because the sentiment is usually not reciprocal. In any interview, the committee is judging you and one needs to be conscious of this fact. One need to be remain alert and active. Listen carefully. If needed politely request to repeat a question. Be polite because a professor's ego can be dangerous.

vii) A prior contact with the subject professors always help even when he/she does not reply. The professor would often remember such mails. Keep the communication precise and short. Like "I would like to join your research group to work on…towards my PhD. I am finishing MSc etc. etc. Please find my CV attached." You may mention your NET qualification and seek some information on the possible programs, underway.

Good luck!

36

Why students routinely fail to understand what is understanding? 'An epidemic & a remedy'

Understanding some subjects is difficult and finding out whether we have a good understanding, or the lack of it, is even more ardous. This chapter dwells on this important issue.

May be it is the English being a foreign language that is affecting our students. But there is probably an epidemic. **Students fail to comprehend what is required and what is meant by understanding in science.** It is so subjective that it is hard to quantify. I think the cure lies in the world of arts and literature and painting. I know that this sounds silly but arts motivate us or even forces us to try to comprehend, to imagine abstract concepts, things that are often beyond immediate expression.

I remember that I became aware of this issue that understanding "what is understanding" was in fact an important aspect of science in my MSc years at Calcutta University when Professor Sadhan Basu started teaching us a course titled "interaction of radiation with matter." He followed it up in the second year with two more courses. They were among the better lectures I heard in my life.

What was magnetic about Sadhan Basu's lecture was his ability to make everything vivid in front of us. I give you

an example. When he was teaching vibrational energy and relaxation, he started the class with the question:

SB: What happens when a diatomic molecule, like hydrogen, absorbs light?

We answered: It goes to the excited state.

SB: What happens to the bond when the molecule is excited?

We: The length increases.

SB: What happens when the molecule is surrounded by solvent molecules?

We: The bond gets hit by surrounding solvent molecules.

SB: What happens as a result of such collisions?

We: The bond loses energy and comes back to the ground state.

SB: Good. What happens to the solvent who gets the energy?

We: The temperature of the solvent goes up.

SB: By how much?

We: Equipartition theorem is needed to relate energy needed for the increase in temperature.

The session and all other sessions were, electrifying.

That was how Sadhan Basu (our beloved SB) used to teach. We realized for the first time how science should be taught and how science should be understood. I gave just one example but every class was such exciting experience. But these days when I discuss science with students, I find that the students do not really appreciate as to what is true understanding. Many of the terms just remain as words. Students think that they understand but in real sense they do not. This really affects when they advance

into complex fields. And I find that this is all pervasive in India. But why do we have such difficulty? And what is the remedy?

The reasons are not too difficult to fathom. First, most of the students go through academics without even once experiencing a good teacher who would have clarity himself and whose teaching could be eye opening. After a class student would say to themselves "Wow! This is how we need to understand things".

I also blame our use of English language. The language should be used in a simple way, not just to be memorized. In the famous story "Alice in the wonderland", Lewis Carroll described the situation most aptly:

When I use a word,' Humpty Dumpty said in rather a scornful tone, `it means just what I choose it to mean — neither more nor less.'

'*The question is,' said Alice, 'whether you can make words mean so many different things.'*

'The question is,' said Humpty Dumpty, 'which is to be master — that's all.'

A teacher must use English skilfully, a foreign language, to explain the concepts. Sadly, this is not happening. Consequently, students seek a recourse to memorization. And, that is when the problem starts and the quest for understanding goes out of the window. Surely, this cannot be allowed to continue forever.

I have always found that arts can play a big role. Pictures can say a thousand words. When we do not have the necessary mastery of the language, we may be helped by (i) pictures, and (ii) the use of our own language. But use of our own language is fraught with difficulty as our students need to write examinations in English.

I have noticed that in Japan they not only use their language but the teachers use of a lot of drawings and pictures to drive home the concepts into the minds of the students. This implies hard work, but they do it. **I think we need to make even school and college teachers aware that understanding is essential and memorization is a strict no-no. We first kill the understanding and then the creativity of students by making them to memorize. It makes me terribly sad.**

A concept often comes with a picture except in mathematics. We need to encourage this view, as Prof. Sadhan Basu taught us many years ago.

37

What an aspiring faculty candidate needs to know/do during the interview for a job in Indian academic environment

Interviewing for an academic position in India is to be treated differently from that in the USA or in Europe. The process here is different, and the prospective faculty candidates need to be aware of this difference, and the effective approach to be taken. Hence this chapter.

Summers are not only the time to conduct PhD interviews but also the time to interact with many aspiring faculty candidates who visit India. It is now a standard method to put in an application, contact your ex-friends and colleagues to arrange for a talk. So, we get to meet many young Indian scientists working abroad but wanting to come back now. When asked why the world is coming to India now, Amitabh Bachchan famously stated (paraphrasing here), We now have the money — before we didn't — so nobody came. Well while Indian institutions do not have that much money compared to the professors of western countries, but there are sufficient enough to get by. The situation is better than when we joined, we were let with Rs. 500-1000 a month to survive after paying for the rents and other such expenses. That was a pitiable existence.

Reverting back to the issue of job interview, one finds many treatises and advice in books with smiling crew-cut faces

of successful executives. These can be picked up from the book shops. These books tell one to be aggressive, dress well with Calvin Klein eye glasses, to connect to people, etc. etc. But, such advice would do not work in the academia.

Okay then what does a department looks for in a faculty candidate? **First of all, knowledge. Second, understanding. Third, humility. None of these three words will be found in books by and for business executives.**

Over the years, I have interacted with numerous faculty candidate. One thing I always try to find out is whether the candidate has/had spent any time reading our web site. We do not have a great web site but we do have one. Some of us have even individual web sites. By now I have lost much hope and do not feel surprised by the fact that aspiring faculty members did not spend even an hour studying the department they want to get a job in. This is ridiculous, but true. It can upset me endlessly, but I have learned to control my reactions. At times, I did have an urge to deliver a stern rebuke to the 30 odd year old boys. Such stupidity!

The lack of research on the department you go for interview coveys to the department, (a) your lack of interest and seriousness, (ii) lack of humility, and (iii) certainly no desire for understanding the problems at hand. A few suggestions below may help.

i) **First** that please visit a department well prepared. Read about it and by doing so you treat the potential department with respect and seriousness it deserves.

ii) Please do not go gaga over your adviser and/or the group at the USA or Europe. The departmental faculty in India is also as good and competent. Many of the faculty members had the best professors, Nobel laureates as their colleagues and advisers, at some point of time. Students who leave India immediately after college often fail to develop a perspective of the situation at home. This of

course is not excusable, and in certain way, it is like not reading the department/institute web site.

iii) **About the job t**alk. Be a bit pedagogical. In Indian science departments (chemistry in particular), the audience is not homogeneous. Spend at least 15 minutes in reviewing the area, starting from basics. Do not be afraid to cover the basics. Also, stick to a time table. You shall be asked many questions. Be prepared to be interrupted. But with all these hindrance, one would expect you to finish within an hour.

iv) It is important that, **when you talk with an individual faculty member, please try** to keep the back-ground of the said faculty in mind, and this implies that you prepare well.

I once had a candidate for theoretical sciences and, when this person was discussing a point, I pointed out a different picture and gave a reference of my book *Molecular relaxation in liquids* (Oxford, UK) a book that I am proud of. However, the candidate did not even bother opening the book or even glance at it. Such a lack of respect towards the work of a scientist who was about twice the age of the candidate really baffled me then, and does so even now.

I tried to understand the mind of the candidate. Why this suicidal tendency? There could be two reasons. (a) She/he was not really interested in the department, or the job, and (b) she/he was not alert during the conversation. Such mistakes need to be avoided.

In this intensely competitive atmosphere, a candidate owes to himself or herself to be adequately prepared before the job interview/visit.

38

Knowledge versus Skill: An eternal debate

We need to combine knowledge with skill, just one is not enough.

Which one is more important — knowledge or skill? On the surface, skill and knowledge are complementary. But sometimes we need to differentiate between the two, especially during the training of students.

Which is more important to present day students? Skill or knowledge? By skill I mean the ability to do something concrete without any help while knowledge implies more academic information.

To be useful to the society, we need people with good skills. We need good pilots, good computer programmers, good doctors and engineers. And, this has been true for ever. Our interaction with nature gives rise to skill; actually demands skill. The end product is also knowledge.

As society gets increasingly sophisticated, it needs more skilful people. Does that mean that the space for knowledge decreases continuously? Or, does skill absorb knowledge as part of the whole? There is room for some discussion here. In some sense, the answer to this question or even understanding of the issues has the potential of dictating the curriculum of schools and colleges.

If we think naively, it seems that knowledge should take precedence. We do need knowledge to start on anything. But that is not how a human child starts learning in life!

Children) acquire both simultaneously when they start walking. Both knowledge and skill are picked up through interactions. The acquired knowledge tells him what is within the domain of possibility and the skill allows him to do the possible.

The two however get separated at a later stage when knowledge begins to involve principles and concepts such as Newton's laws, laws of thermodynamics, electromagnetic theory. In certain sense, knowledge is an abstraction derived from skill. That is how it happened in the early stages of civilization. And this is where the division also starts, and lays the origin of this chapter.

With advancement, it is often hard to keep both going at the same pace and at the same level. The division becomes clear when we separate training into theoretical and practical or experimental. The vocabulary so developed is carried into scientific research. **Knowledge without skill is useless. It may be for one's entertainment and satisfaction but does not come of any use to others and society at large.**

Now I come to the real reason for this chapter. I often find students good at acquiring knowledge but not so in implementation. They become scholars — not scientists. Through the present marks oriented competitive exams, the country is producing such students for dime a dozen and therefore it is easy to visualize the end product of such a defunct system at the PhD level, But by this time it is often too late to make amends. Science is pragmatic and practical.

Among Indian students there is perhaps this tendency of knowledge gathering, without the skills, is ingrained. Therefore, to counteract this tendency, there is a need that the emphasis on skill should be given at an early stage through programmes such as life skills like craft, painting. Performing arts is another such example of developing skills.

39

Can virtues alone make you happy?

(Lessons from Beethoven and Maslow)

"Recommend to children virtue; that alone can make them happy, not gold"

-Ludwig van Beethoven

This impressive and unusual advice seems to be entirely out of place in modern day society where one is least bothered about virtues. I always thought that this was an interesting piece of advice by Beethoven but regarded it, frankly speaking, only a utopia and not an advice to be given to young generation. However, I have now seen in close quarters several examples where virtuous people are indeed happier than their more successful but less virtuous colleagues and neighbours.

We do see now and then statements from psychologists and psychoanalysts that, grateful people are happy, 'it is smart to be honest', enmity, jealousies …, without however any rational or scientific explanation, do not help. As scientists, we indeed need some persuasion that these statements could indeed be true, through some form of a hard core evidence, which can come only from real life examples. However, we can analyse some aspects of Beethoven's assertion by looking at the virtues themselves and see what they usually do.

One thing certain in the very off-set that, here we are talking of long term happiness and not the kind of transitory

happiness that one derives by going to a picnic or vacation, even not the one after getting good marks in examination.

Rabindranath in the very last poem of his life did actually touch upon this subject. This poem was addressed to the Creator where he beautifully articulated his faith that a person who is honest and straight inside, even when he is perceived shrewd outside, gets the ultimate reward in life which is the right to peace.

Let us now turn to the assertion of Beethoven that virtue alone can give you peace. As this comes from Beethoven, it is worth spending time on this. It is almost biblical in its assertion. One thing seems certain to me that the happiness conceived by Beethoven is a long term goal, just as prophesied by Rabindranath through his last poem.

Kindness is considered as the noblest virtue of all. A good man is always perceived as a kind man. I endorse this view. But is a kind man happy? A kind man often makes big sacrifices. My own personal experience is that not only is a kind man happy but he lights up life of all those around him.

It is true that one needs success to be happy. Success provides security and satisfaction. Security is considered the base level in Maslow's triangle of hierarchy of needs– a school of thought pioneered by Abraham Maslow in 1943 and popular with social scientists and psychologists. The highest level in this triangle of human needs is self-actualization that is indeed correlated with success. If you are not already aware of Maslow's triangle of human needs, I recommend you to read about it on the internet. **There is a fallacy here though — success may have nothing to do with happiness! It may even be anti-correlated, as many statistics seem to show.** Here the logic gets murky because one can achieve success by dishonest means, by manipulation and sycophancy. These are the people who

tend to be unhappy. May be even the very root of their drive lies in their unhappiness.

Can this be regarded as self-actualization? Could be. But then something seems not quite right because I refuse to believe that the success through by dishonest means can lead to happiness. It can be difficult to keep virtues as one move along life and can be very demanding. There is famous saying, *you lose wealth, you lose nothing. You lose health, you lose some. But you lose character, you lose everything*. Mighty saying. Character and lost reputation are hard to get back.

I am always reminded of the "Lord of the Rings" by JR Tolkien. "One ring to rule them all". In that story, nine mortal men received the rings from Dark Lord Sauron and became living dead, neither alive nor dead, living in that twilight zone, and permanent slave to Sauron. This is my vision of an unhappy life. To remain virtuous, you need to reject these rings again and again. And, according to Beethoven, and Rabindranath can make you happy.

40

In the world of give and take, it is the giver who ultimately wins

Helping other students and researchers goes a long way in making a person acceptable which is important for career advancement.

From the day we are born, we start taking support from the world. First we take from mother, then father and family. We do not learn the art of giving, easily.

But it is essential to practise give and take. Seclusion is not an answer. One needs to interact, and interact positively. Practise giving, deliberately. If you look around, you will see that everybody wants to take with their palm ever opened upwards to accept. The palm does not easily turn downwards to give. Nonetheless, it is the giver who almost always wins. In Bengali and I am sure in every language, there is a well-known saying "the more you give, the more you receive".

I am particularly sensitive the PhD students and young researchers, and even college students. In academic institutions, have two kinds of people. One class is always eager to take, whether it is help or idea or whatever. Then there is a second group who does not mind giving and sharing. The latter advances, always, by improving, and ultimately triumphs.

Looking carefully around, one finds that givers progress more than takers. A good leader always gives. Takers often are reduced to insignificance while the givers grow

in stature and power. Even success in scientific research follows this pattern. Note that it can be stressful even for the givers, even when they are benevolent. You might be willing to give but you want a good taker in the sense the person receiving the favour must make good use of it. This is particularly true for teacher (giver)-student (taker) relationship. There are endless numbers of stories about this relationship.

Even a brilliant scientist is reduced to insignificance at the end of his day if he fails to create a school and this is only possible by selfless imparting of knowledge and expertise coupled to endless teaching. An arduous business. Everybody quickly recognizes a taker, and either people shy away from him, or he can be used to somebody's goal. However, a giver cannot be easily lured into petty, and sometimes unfair jobs, by showing a carrot. **Therefore, at the core, practice of giving makes one a good man. Being helpful helps, always.**

41

To Students: Self-correction is always a better option than self-justification

This chapter is mainly for students but others are welcome to read it.

When you make a mistake, accept it and acknowledge it clearly. Do not try to self-justify. And do not try to lie or bluff your way out. It of course needs courage to accept one's own mistakes. It is not easy. Not everybody can do it. Actually it tells volumes about one's character. Self-justification is the worst answer to any mistake. It just lowers one esteem in front of others.

I have seen students often try to blame another student or even the adviser. But the major responsibility in most cases lies with the student who was executing the idea or the experiment. In most cases, the responsibility was made quite clear.

I chronicle an incident where I made a horrible mistake. As a result of the mistake the result looked good, very good, and conformed to the expectation of Professor Stuart Rice of the University of Chicago. So, we were all happy that evening when I brought in the graphs to show to Stuart. During the course of my night's work I found a mistake that ruined all the goodness of the result. I checked and checked but alas there was no escape from the unpleasant truth that I had made a mistake in my earlier calculation.

So, next morning, I walked into Stuart's office with the new graphs. Stuart took a look at my face and stated so, there was a mistake? I said, "I am sorry that I did not catch it at that time. He gave a nice smile and said "Biman, it is okay. Only a dead man does not make a mistake". That was really a lesson of my life.

But of course every guide is not a Stuart Rice! But even at the face of reprimand, it makes sense for one be honest and admit mistakes. Your adviser shall ultimately respect you for this. Research is a demanding profession. While exploring the unknown, it is easy to make mistakes. Actually mistakes are part of a student's life and are as much a part of their learning process. Thus one should try to find one's mistake, and admit it with frankness.

Be a winner! Good luck!

42

How to train your mind to excel in studies and in research: The silent force on your side to harness

This chapter up can be useful even to high school students, and certainly to college students and researchers. Please share its message with all.

Not often it is realized or appreciated that one's own mind plays an enormous role in their studies and research. Fortunately, one can harness it for his/her own purpose and towards higher goals. However, this capacity is not sufficiently pursued!

It is pertinent to start with the saying of great sage, Rishi Aurobindo, a deep thinker and the founder of Pondicherry Ashram. Aurobindo said that, for those who try to improve, there is a force to help beyond a point. This force will pull them above the mediocrity. I have often though about this. What is the force that he talked about? In studies, there are only a few who can keep ahead of others. It is not just brilliance and hard work (both needed to some extent) but also the dedication, that is, they possess a single track mind.

Again, a story. During five years of my BSc and MSc studies, I had to commute a long distance by train and bus. I was unhappy about the time I lost every day compared to

my friends in Calcutta, many of whom would just spend 15 minutes to reach college from their home. Finally, I decided upon a strategy. As there was no place to read in a train, even if I was lucky to get a seat to sit down, I started to recapitulate the subjects in my mind. Let me give you an example. Say e.g. that I wanted to derive Bohr's law. I would therefore try to remember every step of the derivation, or recall the steps in synthesis in organic chemistry and in the study of industrial chemistry.

This strategy helped. Later when I discuss with my friends, they would be surprised by my recollection of equations without a book or notebook in front of me. So they went around telling that Biman was working so hard that he managed to memorize everything. I simply could not read much because at home my father would never allowed me to read beyond 11 PM at night and I was returning home mostly after 7 PM – tired. Morning was also out of question. I tried to explain my technique to my friends, but they did not quite believe except Deb Shankar Ray who was then a super-bright young man.

Later, I realized that studying for examinations is like painting a wall – you need to paint your mind again and again so that the paint (here study material) gets a permanent coat. And, this is what helps in exams. This mind empowering technique (MET), as I call it, is not new, and is the age-old technique to remember things. But for me, it was intuitively discovered out of necessity to survive and practiced diligently for long. I scored highest in Organic Chemistry (Yes Sir! got 77% in MSc Part I), in Inorganic Chemistry and similar in Physical Chemistry. These were huge marks in Calcutta University in 1970s. I cited these numbers just to substantiate the utility of my MET. The trick is the use of repeated memory refresh without any book or notes.

Now back to Rishi Aurobindo. During his later life, he lived inside a small room on the first floor, trying to unify eastern and western philosophy. He never left the room. The result was the epic book *Savitri.* Rishi Aurobindo has been an outstanding example, that MET can do wonders.

I am not sure, but the oral education technique practiced in ancient India probably was also a mind training exercise. It was not just memorization from a book or class notes because you are with other students in a group. Swami Vivekananda was a great believer in the power of mind.

This is where internet and mobile phones (with endless messages and WhatsApp etc.) are ruining our students' mind. It interferes seriously with our mind, make it restless. If I had the power, I would have forbid students' mobile from 7 am to 8 pm and do so for their own good.

A serious student should keep his/her mind free and dedicated his total attention to the subject or research. Rabindranath Tagore said a memorable sentence in one of his plays that, it is the mind where all worshiping is done, the temples are just the outside."

Thus the message is that place mind over matter if one want to do well in studies and research.

43

For Students: How not to Self-destroy but to Improve

Students often go in a self-destruction mode, out of frustration, along with ignorance about the need to ask for help.

I find many good students self-destroy themselves – most often by not following certain simple self-preservation strategies. I have also seen many not-so-good students improve tremendously over the 4-5 years they usually take to finish PhD. This seems like a natural phenomenon: some students improve and develop tremendously while many do not. Some actually go down with time. And the fraction of such students is not small. Such students were good to begin with, but then with time, not only they either stayed static or even deteriorated.

This could be attributed to a failure of our system. Students are supposed to improve, especially during PhD. This is particularly true for Indian PhD students, because we do not get a good undergraduate education. So PhD training plays a big role. But why then so many students fail to improve?

The system is certainly to be blamed in many cases. We fail to guide in the truest sense of the word. A department and the adviser need to be nice to the students but be correct to them. I always tell students to beware of their sweet-toothed adviser or professor.

Most remember the teaching of Dronacharya of Mahabharata a great teacher. However, he was also strict and often harsh. He did not even allow Bhima and others to release the arrow from the bow as they saw things other than the eye of the bird they were supposed to shoot at. Only Arjuna answered that his only focus remained on the eye of the bird suspended from the tree while rest of the world was non-existent for him.

However, such good teachers are rare anywhere in the world, and although, they should be the most valuable and most celebrated entities of our society, it spends time and money on cricketers, movies and politics. However, one needs to do whatever he can in this misplaced ecosystem.

The following are the steps to self-improvement as I have written (partly) once before.

i) First, learn to have fun during the 5 years. This will help you keep yourself engaged. Friends are the best source of fun. Also focus on your own pleasures, such as music, movies, story books.

ii) Learn to tackle failure and rejection. This is now more important than others. This is like facing bad weather, long, dark, cold winter in Denmark. In research also, you need to train yourself to be weather tough.

    There shall be difficulties. Failures. Rejections. Hardships. But never give up. My friend Professor Yoshi Oono (an extra-ordinarily smart scientist) always told me, "Biman, you need 3 Ps to do science — Passion, Practice and Patience. And the last P is the most important one." I found this true in my own life.

iii) Form a group of friends with like-minded students. This is important. Must do self-study — better done in a group. I find most groups these days study their own papers or just report work in group meetings. You should spend time reading important papers in your

area of research. You shall find such an effort opens up many avenues in your mind and work.

iv) Time is short, and getting shorter — too much to learn and do. So, stay away from mobiles and internet unless you use them for good purpose. These gadgets consume enormous time. I see young people spending unreasonable time on mobile and internet. Know that these are sheer waste of time. A famous colleagues made the rule that he would not look into e-mails or news before 1 PM. He told me that this helped him enormously. Tell your friends not to call before 4 PM.

v) Be relentless in pursuit of results and excellence. Never lose faith, even when you are failing. Many good students easily have self-doubt. It seems to me our good students are a bit more fragile, easy prey to the attack of self-doubt.

vi) Learn to communicate your fear and worries — with others, friends, adviser. Solution comes out of discussions. You can also get back your faith.

vii) Try to teach your self, by imagining yourself as a teacher in a lecture. This will bring to your mind clarirty and questions, that will not occur to you otherwise. This will mprove your communication skills and prepare yo for extempore statements.

Give some time for your self to analyze your day, your plans for the next day. Remember that there is enough room at the top for many of us. So, do not lose faith.

44

Creativity and quality of mind

Quality of mind plays a hidden role in creativity. This can be nurtured and developed by reading good books and listening to good music.

Robert Zwanzig, my primary mentor, was a man who demanded perfection everywhere. He is credited for making some of the most fundamental contributions to the area of time dependent statistical mechanics, relaxation phenomena, theory of liquids and many others. A exacting but a proud man. He set very high standards. I use "very" here as an English man (without being one!) who use adjectives carefully and miserly, most in Indian add "very" as a super-adjective everywhere. My students always write "very interesting", "very good", as if the main adjectives "good", "interesting" are never enough. It might reveal our excitable character, but does not do good to our English! Remember, good is very good, and hard is very hard, unless quantified.

Zwanzig was enormously respected across the comities of Physics and Chemistry. He became a Fellow of US National Academy at the age of 35. He was among the last two in the Nobel of 1978 and may be some politics removed his name from being a joint winner, and the Nobel was given to a single person, an act our community did not appreciate.

In my world, any praise of Bob Zwanzig can not be enough and, I always get carried away. My intention is to quote one of his observations. When distinguished visitors (from Physics and Chemistry) came to visit him, it was

his practice to keep the students in his office, so that we could see/interact with the visitor together. It was partly because of his shyness and partly because of his dislike of being visited. He was a private man.

But before the visitor's arrival, Bob often used to give a two-minute introduction about the person. It was almost never negative and was usually kind and considerate but never exuberant. I remember that only on two occasions he praised the expected visitor by stating, He has a good mind. Only later I realized that it was one of the highest praise in his book.

Of late, I have been thinking about, what did Bob mean by "good mind"? What is, or who has, a good mind? Bob certainly implied a creative mind but must had also included clarity of thinking in his definition. Since I had known Bob well, I think that he would include choice of problems in science. Bob was careful in selecting his problems. Only a few ideas and areas excited him.

Now, what defines a good mind? What is the advantage of a good mind? How does it help? To answer these questions, I thought it was best to look around among the people I know well, personally, and see if I could find further attributes. One correlation was easy to find. People who are too jealous or vindictive or harmful to others, often fail. I have seen numerous examples. Problem of course is that, India has a small sample of good scientists to build a good theory. So, I also looked abroad. I have a few amazing friends and colleagues whom I have known well and many of them made significant contributions to science. When I analysed in detail, one thing became clear: Bob's good mind included a detached mind that are simple because these minds do not have time to spend or waste time on issues or subjects that distract them from their science. They never try to "act clever."

Charlie Chaplin chronicled a nice story about Einstein. This was told to Charlie Chaplin by Einstein's wife. One morning Einstein was rather absent-minded (observations by his wife) and started playing piano which he played for half-an-hour. He suddenly stopped (did not say "Eureka"), went up-stairs, and did not come down for two weeks. He did not see anybody, no interaction — food was taken upstairs by his wife. But when he came down from the upper floor, he had a bunch of notes in his hand. And, that was the solution of the general relativity.

It is an amazing story that continues to impress me. The fact that Einstein liked music is widely known. But that he could spend alone for 2-weeks working on a problem (he never came down), tells you his involement with a deep scientific inquiry of his determination, concentration and the state of a mind which was not to be and nor was allowed to be, disturbed.

Thus, an outstanding mind for science would have the following credentials.

(a) It can think continuously, and not be distracted easily.
(b) It has a clarity of thinking,
(c) It has the ability for a detachment which proves extremely useful when needed.

On the other hand, minds that are materialistic, overly clever and manipulative can never do good science! In fact, they do more damage to science than simple minded people. But people do not respect them. Charlie Chaplin also famously stated (paraphrased) that twentieth century did the right thing in paying respect to Einstein that he so richly deserved. However, the same is not true for many others! Actually, I often see that the people with Bob's "good mind" are pushed around or pushed out, with the place taken by undeserving people.

We are often given examples of ill-acts of outstanding scientists (like Newton's treatment of Leibnitz). However, if you analyse these a bit carefully, you discover that such acts happened at an age when these good minds ceased to do creative work.

Let the students and younger generation be aware of this. Even if we ourselves are not that good, we should protect the few who are good and can deliver. I was once told that the unique strength of American academic system that good people are not destroyed there, like it is done in many other countries. I hope that it continues to be true and also adopted in other countries. The society and a Nation as a whole can benefit from the protection and freedom to the ones with Bob's "good mind."

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A bit of Dale Carnegie: Scientific behaviour (also mannerism), temper to be cultivated by all students

Academic community is different from a business community. This simple statement could have profound implications in one's behavior.

Whenever I think of how one should behave and develop a practical attitude for public behaviour in laboratories, during conference, large meetings where they are with other scientists (some famous and acclaimed), I am reminded of several (embarrassing) situations from my PhD days at the Brown University and at James Franck Institute, University of Chicago. These memories are from a distant past, but I believe are probably more relevant these days as well. The ways to behave and interact has become increasingly important in the present times.

My first memory from Brown days is still so vivid and it feels like as if it happened yesterday! In my third year, we had Professor Robert Zwanzig as the Appleton Lecturer. This used to be an important occasion for the department, with lots of fanfare. The speaker was expected to stay a day or two extra so that students and faculty can interact with him/her. I remember that at 2:30 PM on the day of the lecture, we went to meet the speaker. By that time, I had already read many of Zwanzig's papers, knew that he was

a great scientist, and was eager to meet and talk with the great man. He – a tall and big man with the steely beard, was sitting near the centre of the room, smoking a cigar, I watched with a lot of jealousy as several other students stood next to him and were talking freely to him. I just got so tongue-tied that neither could I approach him nor could I speak. Of course, later I worked with him and published a few good papers, but I still repent the chance I missed. I had several questions to ask but was too afraid of doing so. The interaction could have remained a nice memory. An opportunity missed!

Similar things happened several times, during Gordon conferences and in other meetings. For example, I could never talk to Prof. S. Chandrasekhar at Chicago although I used to meet him almost regularly as I used to sleep at the RI Library (4 AM to 8 AM) and his arrival used to wake me up. I thought he must have thought what a jerk I was to sleep in the library — only much later did I realize the opposite was probably true. Similar situations repeated with other Indian students who shy away from famous scientists, feel embarrassed or intimidated. I sometimes introduce them. I see this happen regularly in our PhD entrance and also comprehensive oral examinations.

I have often wondered about the reason for our hesitancy and fear. Why? Is it the same in other disciplines or is specific to chemistry/theoretical chemistry? The same happened when I first met Rudy Marcus who later became my good friend (my good luck). I think that this is due to two factors; (1) Schools, where we are taught to show too much reverence for authority and (2) the Indian culture that fosters worship of great people. Neither is needed. We do not know and are not trained to develop a behaviour supported by self confidence, so that we are not afraid. We are either trained nor encouraged to ask questions. Actually we are trained

for not asking question, reverse! We are not sufficiently admonished for being "too shy".

Rabindranath said a great many things on this particular aspect. In an uncharacteristically direct and famous song, he wrote "Over-powered by hesitation and shyness brings shame to oneself, just as imagining of danger make you lose heart …. get rid of fear, and conquer the freedom within you." *(Sankocheri bihwvolatha nijeri opoman, sankoteri kalponathe hoyo na mriyomana*). I translated only the meaning/implication and not the beautiful rhyme which is far beyond me.

Thus, to be a member of the scientific community, a few behavioural patterns and attitudes need to be developed to become a meaningful and a contributing member.

i) Without being arrogant or imposing, talk with people. React and also venture your opinion. You need to cultivate this.

ii) Do not keep quiet when a question is asked. Do not be afraid of being ridiculed. Participate, participate, and participate.

iii) Most scientists welcome questions, discussions, and comments. Never fail to approach and talk. But be sincere and articulate.

iv) Discuss a lot with your friends and colleagues, especially when out of the Lab/office. Problems should never leave you.

v) Read things other than science and read widely so that in any discussion you can participate with knowledge.

Being an active participant helps. Science is a way of life. You should never be away from research and never stop to think. It is truly enjoyable.

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Use self-appraisal as a tool for improvement, in research and in life

Self-appraisal is different from self-criticism. It is an objective evaluation of one's abilities and also limitations. It can be a valuable tool in one's development.

These times of pandemic are difficult times, when due to circumstances beyond anyones control, a student has been alone, for months. This has been a long time. However, such times should not be wasted. I found that many students are entering into a state of frustration and depression, while some are taking it easy. There is an atmosphere of uncertainty. Advice, might not work. Under such conditions, I recommend self-appraisal.

Whether in studies, research, sports and in every sphere of life, self-appraisal is a valuable tool in ones struggle to establish his credentials to go ahead. The cardinal principle is that self-help is the best help. This additionally fosters honesty and integrity.

Doing research in India is demanding and arduous. I often see students struggling to make progress, having little clue about the direction in research. There could be many reasons for this, maybe the student is ill-prepared, maybe the frequent changes in direction and/or intervention of the thesis adviser wanting to control much and demanding much. Such an environment confuses and demoralizes the students.

Here I suggest a method for self-appraisal/help towards maintaining a focus and avoiding frustration. Many of us practice this and everyone connected with science at all levels can carry out self-appraisal at regular intervals. If done honestly, self-appraisal leads to improvement. Here you are made/forced to come face-to-face with yourself, to find out how much work you are putting in.

Self-appraisal is different from self-criticism, although the latter is often the outcome of an honest self-appraisal. Candidly put, the latter is a critical and detailed evaluation of one's day-to-day activity in respect of the perspective of one's goals and ambitions.

This is how to do it. Make some time say once a week (you can do it daily too), and think about how you spent your time each day. Ask yourself: what did I do with my time? What was my goal and how much I accomplished it? Was I nasty to anybody in particular? Did I help at least one person?

In self-appraisal, one inquires about one's limitations, shortcomings, strengths and work habits, with scope for improvement. This is akin to the SWOT analysis in industry, alluded to earlier. It is better done in a group, and in writing. If one is not selfish, one gets the benefit. If one is honest, one gets the benefit.

Actually, in a team, an appraisal is a sure way to strengthen the team, helps in finding out the contributors to the team, and also those helping themselves. Learn from each other. Note that selfishness here has a different meaning – mainly avoiding work. In science, one expected to find his own work and his own problems and no one should wait for instructions to get started. *Self-appraisal is the key, and self-improvement is the goal.*

My first encounter with self-appraisal came from my father. Those days (in 10th or 11th grade) I suddenly became

interested in studies. God only knows why. I am now not sure about the choice. Many of my friends always discussed how they study after returning from school, sometimes after a small nap, etc. I was not allowed to do that. But I started on this, especially till 5:30 PM when my father would return. A few days father came early and found me at study around 5 PM. One day he asked me to make a chart of time and see whether my efforts were fruitful in terms of extra time I spent studying. I did so and found that he was right! By staying one hour or so extra and going to play at 5:30 PM, I was returning a bit later and then wasting time as I felt that a lot of studyies was already done. I was made to carry out some exercise while attempting to study at nights beyond 11 PM. Only getting up early to study was not frowned upon.

I followed up on this practice later — especially while working as a Ph.D. student and a post-doctoral fellow.. I kept an eye on the times out of the laboratory or socializing and gossiping. I knew what was wrong and how I committed to that. For example, I found out that I was taking too long a break for dinner, more than two hours away from the lab. So, I cut down on that duration. Such self-appraisals kept me on track. These are like a blood test or check-up at regular intervals. For example, I know what I did wrong during the lockdown, I know where I wasted time and effort, I know where and how I was lazy. My self-appraisal unerringly pointed out one limitation that I often did not sit down to do analytical work like I used to do before. Analytical work requires discipline and more effort than I put. This makes me uneasy.

I know that the four major awards I received did not particularly affect me. This was good. Maybe had I received them earlier, it would have been different. I find that by and large I worked hard, stayed involved, in addition to walking more than 90 minutes each day, and doing house

chores. That is, I was not lazy and irresponsible. The key was to stay involved and like the work. Responsibility is the right word. The reason I could stay involved was that I continuously found new things to do, but that needed effort. Thing sand ideas does not fall from a tree. Whoever waits for directions or push, is bound to fail and makes any team weaker.

It is easy to be responsible for one's self and to family members but that is natural. However, one needs to be responsible to the profession – the one that pays your scholarship and salary. It is also a question of morality.

Let me wish you success in this endeavour.

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Get out of your comfort zone to do well in research

The best research is always done when one learns to new ideas and new subjects. Thus, one must explore new avenues that are difficult and by tread on territories, uncharted as yet.

It is commonly said that the life begins at the border of your comfort zone. The statement is more true in science research than probably anywhere else.

Let me explain. Most of good research occurs out of nowhere or by luck or accident. Of course, there are isolated cases, but most of the good results come from a certain combination of knowledge, understanding, and of course, continued hard work. But hard work alone is not enough.

At this point let me state a few "nectars of wisdom" that I received from Professor Robert Zwanzig. I was lucky to work three times with the great man. Bob told me a few secrets of doing good work. First, always look back, go to the library, read old journals. At our time it meant 1950-1970 or so. He commented that many interesting problems addressed at those times could not be solved, but the ideas were there. He called them "lost diamonds".

Second, follow outstanding scientists. He told me that he benefited a lot by following Ryogo Kubo and Melvin Lax. Later I found that indeed there were unmistakable signs of the influence of both on Bob's monumental work.

Third, always devote time to learn new techniques. I found him to do so even when he was nearly 65 years old. I give you an example. In 1991 I was using a technique to perform Laplace inversion. The method was given to me by a colleague of mine. I checked and figured out where it would work and where it would fail. When Bob came to know the technique, he was interested but sceptical. He spent almost two weeks to discover for himself the mathematical background, wrote his own code, and finally told me that he would use it in the future and developed a code in Mathematica, in case I needed it. He was happy that he could all figure it out by himself and was a bit annoyed that I did not do the same.

Thus, to do well in research, you need to leave your comfort zone, search continuously for new ideas and new problems, and learn new techniques forever. This is different from "thinking out-of-the-box" that Professor RN Zare (Dick Zare) always mentions in his lectures. This thinking out-of-the-box comes later, at a more mature age, and more difficult to start on. Please read Prof. Zare's comment that is reproduced. *"Thank you, Biman, for mentioning me in your blog. I think anyone willing to confront an unsolved problem leaves their comfort zone. I advocated thinking outside the box as one possible strategy for arriving at a solution".*

He told me a couple of more tricks and shall share some time in the future. Bob was generous in giving away ideas to the younger generation, although I did not find the same magnanimity to scientists of his age group. With us, youngsters, it was different. But everything that Bob told implied that we live day-to-day life consciously, searching for problems, for techniques and to be active in pursuit of new methods.

All these imply that scientist must leave their comfort zones, at least a few times every week. They must read a lot and think of for novel unresolved problems. Good problems do not fall on your lap from a tree, but you can find them only when you are consciously looking for them, and have developed the ability to recognize one when it does appear. And, always remember, even chance only favours a prepared mind and the mind gets prepared with lots of serious thinking and concentration, buttressed with reading widely and intensively.

One must remember that good ideas are not dime-a-dozen. To quote great Linus Pauling when asked how he got great ideas. His answer was that to have one great idea, one needs to have many good ideas. Another nectar of wisdom. A real pearl.

That also means that you need to be constantly in search, like a treasure hunter. Just as a treasure hunter leaves home, goes to the wilderness to search, we need to do the same. But that means one need to have a true yearning for the unknown, for the mysterious, to explore. Actually, these attributes distinguish a creative scientist from the rest.

Some cultures and maybe some families are good in inoculating these aspirations, maybe a yearning or even restlessness. In England, during the nineteenth century, young men used to leave home and the secureity of parental care to search for adventure and new fortune. So many of them perished, but they did build a great empires which we can criticize today, but this was indeed formidable, and respectable in its own time.

Let me wish you such restlessness and yearning! Rabindranath also said, in his wonderful inimical way, "The peace and worship at home is NOT for the ones who want to achieve something in life" (*Gharer mangol shankho nahe tor*

tare, pathe acche kalbaisakhir ashirwad, sei tor rudrer Prasad). You shall be blessed by adventure and storms, let that shall be your prize.

Well, I digress. But all these add up to the same thing: step out of your comfort zone of knowledge and expertise.

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Managing the contrasting role of obedience and discipline
(that students need to practice)

Too much obedience is not good for research but discipline is. There is an intricate relationship between the two.

In my considered opinion, when you grow up in a strongly and internally coupled and constrained culture like in India, there are certain inherent limitations when one comes to a life in research. One of them is the expectation that students should obey, that they should do what they are told or instructed, sensu-stricto. Such a forced expectation inculcates a dangerous and harmful habit in students that they should wait for the order with the fear that the professor/guide/ seniors might be unhappy if anything new or original is done without their permission or knowledge. This runs deep in students. I know that students are even told that that they should not or need not think and that the seniors/supervisor shall do all the thinking". As if this is offered as a service to students by the guide.

Young students should not be caged – they should be allowed to fly freely. There is tremendous joy in flying, in thinking free and exploring new ideas. Students should not be deprived of this joy – like in Chekhov's famous story, they should be encouraged to fly. The often used Tagore's poem where the mind is without fear … is worth keeping in minds.

Our school education, inherited probably from old Sanskrit-based schools in ancient India, and substantiated by the British for their good, promotes this. As far as I can understand, a part of education was almost always memorization-based and also a close interaction between the students and teachers. Obedience was strictly enforced, along with certain rigor.

Wholesome discipline is good but too much obedience is, while good for the army, is not good for science. Students should not be too submissive. They should learn to question. Creative people always like to explore new avenues. Though desirable, this is not always encouraged.

Such an ecosystem originates from a lack of excellence. We hardly see any hard-working eccentrics, like Leo Kadanoff coming out of Barus Helley building in Brown University at 4 AM. Almost every morning, Stuart Rice coming to James Franck Institute at 8 AM even on 26th December cold wintry morning. It is good and motivating for students to see such hard eccentric and outstanding scientists and witness their dedication to work.

Perhaps the most notable exceptions today are the music schools, where rigorous training is provided for Indian classical music. Indian dance would also qualify for this. While obedience is a necessity here, an initial talent is a prerequisite. In many western countries, sports provide a glorious example of a disciplined drive towards excellence. We miss much of these in present-day Indian life, particularly in urban area where the young generation is immersed in the internet, mobile etc.

I often find that students have no clue as to how much work he/she needs to put in, how far to go and where to stop, how much care and rigor are needed. They remain clueless because they expect guidance but in research often there is nobody to tell them when to stop. True, that even the

advisers are also clueless and some level of self-help, and introspection is needed for one to calibrate his trajectory for life.

Rigor is an essential part of science. We find this in abundance in western countries, particularly in German science and in Japan. In those countries, scientists do not stop in their pursuit. They do not stop after doing a little and quickly write a paper. Such quick publications never help. It might give a paper (good for the short span) but a bad/poor training for students. Actually, often students, without a definite goal of success, like to explore, to go beyond, if allowed …

There is a rule of thumb in research pursuit: do not stop unless you have to. Go as far as you can. If you have to write a paper on the way, do it but pursue the problem as far as you can do. There is nobody to tell you where to stop but the fact is that there is no need to stop. Here obedience does not help. Maybe not even discipline! It is so hard to define creativity as it never follows rules. But one thing is certain, a disciplined hard-working life is a must to be a creative person. Nothing comes easy and nothing comes free. We do not get to see the hard work.

Remember the famous line in the poem *Ulysses* by Lord Tennyson, "My purpose holds to sail beyond the Sunset." That is, never quit, never give up. In our Sanskrit there is the same saying --"Charaivethi, Charaivethi ".

Keep walking. Go forward. One day the world shall belong to you.

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In an academic career spanning over more than four decades in which he has traversed over a wide landscape of physical chemistry. His seminal contributions often helped building up new areas, by earnest determination, scientific excellence, intellectual leadership and tireless commitment. He has been a great mentor for numerous young theoretical physical chemists of India and an insightful collaborator with leading scientists worldwide. He has published close to five hundred, many well-cited, papers in reputed journals. He remains an internationally renowned physical chemist. He has received a large number of national and international awards and recognitions.

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