NATURE’S ACTION CHEMISTRY

PROF. SABYASACHI SARKAR

“Prof. Sabyasachi Sarkar (born May 17, 1947, in Birbhum, West Bengal, India) is a chemist known for his work in bioinorganic chemistry and nanoscience. He studied at Ramakrishna Mission Vidyamandira and the University of Calcutta, then earned his Ph.D. from Gorakhpur University. After postdoctoral research in Germany, he joined IIT Kanpur in 1978. There, he worked as a Senior Professor and later became the Head of the Chemistry Department. Prof. Sarkar’s research has helped us understand metalloproteins better. He worked on models of heat-resistant enzymes and fish enzyme replicas. He also proved that carbon dioxide binds to magnesium in chlorophyll during photosynthesis, confirming a 100-year-old theory. In nanoscience, he developed water-soluble nanocarbons from low-grade coal. These have been used in plant growth, bio-imaging, and drug delivery across the blood-brain barrier. Beyond IIT Kanpur, he has held honorary positions at IIEST Shibpur and Ramakrishna Mission Vidyamandira. He became a Fellow of the Indian Academy of Sciences in 1997. Throughout his career, Prof. Sarkar has worked to advance chemical sciences while mentoring and guiding young researchers.”

INTRODUCTION

Well, let me start from the beginning, back in Jamtara, that is where my curiosity—my *khyal*—for science was first sparked. You see, I had a good school— it was a village school—and I was fortunate to have a few great teachers who truly sparked my curiosity. My father, a lawyer, not knowing much about *biggyan* (science), would bring me science books whenever he visited Kolkata. Being a clever father, he chose physics and chemistry books written in Bengali—can you imagine? That's what a little boy can understand, a little bit elevated, of course. I used to pore over those books, trying to make sense of what was written. Most of it went right over my head, but there were these small, simple experiments described. Like in that old book by J.R. Partington - the descriptions were so nice: ‘*This is the way it is to be done*.’ That’s how it all began.

Now, when I was in class eight, I asked my teachers how I could do one of these experiments. He just laughed, smiled, and said, "Well, it will be difficult, but nevertheless, you try". Then comes the best part of the story! I asked for a little bit of phosphorus - white phosphorus - from the college lab. The teacher asked why. I told him I had read that when it comes in contact with iodine, it burns with a green flame, and I wanted to see it myself. "You are just a kid," he said. "I won't give you white phosphorus - it will burn you, and you can get tetanus from a phosphorus burn!”. You won't believe what I did! I had a friend whose father made pottery. I made a simple earthen retort and got some bones from a butcher shop. After cleaning and burning them, I extracted calcium phosphate. Then, I mixed it with sulfuric acid to produce phosphoric acid, added some carbon, and heated the mixture underwater. Through a simple distillation, I managed to get a little bit of waxy, white phosphorus. Carefully, I lifted that waxy substance with a glass rod and touched it to some iodine powder. The moment it flashed into a green flame – oh, *oh, I can’t tell you how satisfied I was!* I went to my teacher following this and said,

"Sir, you didn't give it to me, but I did the experiment by myself!" That was in my class eight. I also remember the Barlow’s wheel- a wheel that keeps rotating when electricity flows through it, completing the circuit with a pool of mercury. The teacher refused to give me mercury. So, the two thermometers in my house… well, I sacrificed both and used the mercury for my circuitry! My mother - oh, she scolded me badly. But my auntie stepped in and said, "*Don't scold him, these are the first steps where one can learn something*". That was my *aarombho* -my beginning, and from there, my bhalobasha, my inclination, for doing experiments in science truly started.

Another key reason I chose chemistry over physics—I can still remember my pre-university days, especially the classes at St. Xavier’s College in Ranchi. I was assigned an experiment to determine the latent heat of vaporization of steam. Instead of 540 cal/gm., I got 1100! Furious, I asked my teacher why my results were so far off. He simply said I must have made a mistake and told me to repeat the experiment. The next time, I got 280. I asked if I should try a third time. He said, “These old machines have their limitations—you won't get better resolution. Don't waste your time.” That was physics for me. Then came chemistry. I worked with copper sulfate solution. - it's pale blue. I added ammonia first, and as expected it gave a pale blue precipitate. Just as described in the book. Then, when I added more ammonia, the solution turned deep blue - exactly as described. I decided then, "*I'll go for chemistry because if I follow the steps properly, it works*!" So, I left physics behind—partly because of, well, a not-so-inspiring teacher.

After pre-university, I moved on to B.Sc., but due to the exam system at that time, our results were delayed. By the time I reached Kolkata, the admissions at Presidency College were closed. I was considering to go back to Ranchi University for my B.Sc. honors in chemistry, but before that, I thought, "Why not to visit Rama Krishna Mission in Belur Math?". Since I was young, I used to visit the RK Mission Ashram Branch at Jamtara. For the first time, I saw a college located just to the left of the front gate of the main Ramakrishna Mission at Belur Math, Howrah. Driven by curiosity, I walked in casually. It was a Sunday. I noticed an elderly monk standing in the main driveway watching me. I walked up to him, later got to know that he is the Principal- Maharaj, and offered my “pronam” (*a respectful Indian salutation to the elderly). He simply stared at me and asked, "Are you willing to study here?" Just like that, I said yes. Then, he tested me – but not on science, mind you! "Write* one page about Swami Vivekananda", he said. I wrote something, I don't even remember what. But it was okay. That Sunday, by pure accident, I got into that college. *And what a great college it was*. Later, I learned that this college has been the dream college as proposed by Swami Vivekananda with the motto, “*man making education*”. It nourished everything for me.

You see, in the evening, there was a prayer every day at 6:00 pm. However, In the chemistry lab, experiments often went on for a long time, so sometimes we missed the prayer. One day, the principal said something that stayed with me: 'You are exempt from prayer because working in the lab is a prayer in itself—just as meaningful.' He went on to say, “If you can’t complete your work, I’ll give you the key. You can open the lab on Sundays and continue your experiments—if you feel responsible enough”. That privilege he gave us changed something for me – it was the start of doing something of my own. It ignited the icchha -the deep curiosity - to experiment more. That shaped my attitude towards further studies. Then, after my M.Sc., I was searching for research guidance. One of my professors suggested I speak with Professor P.B. Sarkar. He was a direct student of Acharya Prafulla Chandra Ray and still working as an emeritus scientist at Science College, Kolkata. He told me, “He might have a research position for a student". So, I went there and said, "Sir, I want to work with you." Now, my professor had warned me, “Be careful. They are too much swadeshi!”

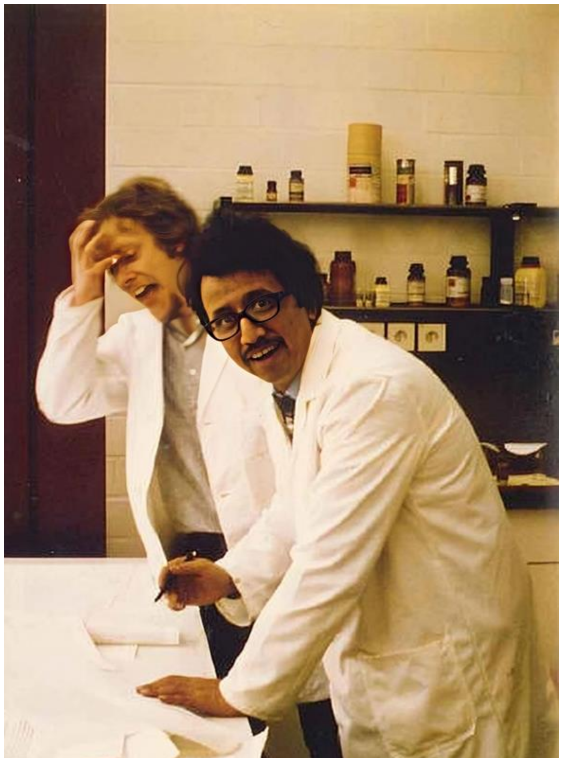
To embody the pre-independence Swadeshi spirit, the professor boarded a ship at Kolkata harbor for the University of Sorbonne, France, dressed in European attire. He spent eight years there working with Professor G. Urbain, renowned for his work on lanthanides. But on his return journey, he changed out of his European clothes while still on board and stepped onto Indian soil wearing traditional Bengali attire—Dhoti, Punjabi, and Chadar. My M.Sc. teacher said, never call him 'sir', always address him in the Bengali way, '*Mastermoshai*'. If you say 'Sir,' he would get angry! When I met him, he just said, "Okay, start your work". I asked him, when and he said "now" and that was it. He handed me his lab keys. Sometimes, he shared stories about science from France, the rest of Europe, and ongoing research in Kolkata. He visited the lab frequently, and his friend, none other than Boson fame, Professor Satyendra Nath Bose, would often join him. They would talk in front of my lab for hours, where I was working, and I would listen to those two old giants. The age difference was striking – they were in their 70s, and I was just 20. A relationship like 'grandfather-grandson' one can understand. From them, I learned not just about science, but also about ambition, the race for recognition, and, most importantly, the belief that nothing is impossible.

I can give you a simple example. I wanted to study the hydration of carbon monoxide to form formic acid and the reverse dehydration reaction. So, I asked Mastermoshai how to proceed. He said, "Get the Raman done." I said, "Raman spectrometer is not available". He remained stone-faced. He said, "So what? You just build it. It's not that difficult. You build it". Yes, sir! That's how he worked. He often shared stories of how they dreamed up ideas, built them, studied them, and then took them apart. Now, if you ask anyone today to build a Raman spectrometer, they'd say, "Are you crazy?" But that mindset—the belief that I could figure things out—sharpened my analytical skills, and I started experimenting and exploring on my own. I used to report only the successes to him, never the failures to avoid scolding about my wrong thinking. I knew he would get angry.

I was given a free lab, enough equipment, and enough chemicals. Money wasn't a problem since I came from a well-to-do family, and my professor even passed his research fellowship on to me! So, I was happy, eating, sleeping, and spending most of my time in the lab. I used to stay until 9:30 or 10:00 at night when the chowkidar would come and drive me out. In the morning, I would enter the lab at 8:00, go to the university science college canteen when it opened, and ask, Batu-da, the canteen guy, for a cup of tea. From 8:00 a.m., when the canteen opened, until 10:00 p.m., when the chowkidar finally kicked me out, I was completely immersed in my research. I felt like- "I am monarch of all I survey, my right there is none to dispute." In between, Jagadish da, the lab helper, would bring me lunch—bread toast, stew, and a cup of tea—all covered through our monthly payments.

I had the free time to do all sorts of experiments -some of them were quite dangerous. For my work on synthesizing cyanide complexes, my professor even handed me a bottle of potassium cyanide! It had been confiscated by customs and sent to the university for research. He said, "The purity is not great, only 80%; you have to purify it before its use". There I was, just 20 or 21 years old, handling impure potassium cyanide. I mixed it with acid to generate hydrogen cyanide (HCN)—a deadly gas—then dissolved it in alcoholic KOH to get pure potassium cyanide! I carried out this distillation entirely on my own, refining it into those pure white crystals. I used this purified KCN, and I enjoyed every bit of these adventures. That training proved invaluable years later when the Indian Defense Laboratory entrusted me with a large consignment of KCN, confident in my experience with cyanide from my days at IIT Kanpur. I was very fortunate and happy to have access to such materials and use it for constructive new research. And look - I'm still alive!

Thereafter, came my international experience. I was fortunate to work with a German Professor. People used to call him mad, you know. They'd ask me how I could stay with him for so many years. But I knew him very well. Sadly, he passed away last year at his 86. But his dedication, his passion for research, was beyond comprehension. A simple story: at 9:30 at night, he'd be in his office, and I'd be in the lab in Germany. After finishing up for the day, I walked back to my apartment, had a late-night dinner, and tried to unwind with some TV. Back then, I enjoyed watching John Wayne or Clint Eastwood westerns. Suddenly, my doorbell rang, at 1:30 in the night! No mobiles those days. I'd open the



Verifying an unusual tetragonal Mo4 disphenoid $[Mo_4(NO)_4(S_2)_6O]^{2-}$, a new highly symmetrical polynuclear complex with Dr. Werner Eltzner

door, and there was Professor Achim Mueller standing. "Yes?" I would ask. He'd say, "I have a great idea!" He'd come in, sit on the floor, spread out all his papers, and we'd dive into discussions—'This can be done this way, that can be done that way'—sometimes for up to two hours! Then he'd say, "Now we are tired." It would be 3:30 or 4:00 in the morning. He'd say, "Okay, you have never seen how the downtown looks in dead night. Let us go for a ride. I want to show you". He'd drive to the city center a couple of times and then drive me back to my apartment, saying, "Okay, at 8:00 morning we meet". And after just a few hours of sleep, I'd be in the lab at 8:00, and there he'd be, already sitting. That was madness! But I enjoyed every moment with him. His dedication was boundless, his idea was, '*sky is the limit*'.

Our first inspiration was nitrogen fixation by nature—how plants use their root nodules to carry out this process in the open environment. The enzyme responsible for nitrogen fixation was recently found back then to have molybdenum, iron, and sulfur at its active site. At the time, we were experts in molybdenum-iron-sulfur chemistry, so we jumped at the chance to replicate a similar assembly in a test tube. Immediately others like Americans, British joined in such working model study. Meanwhile, X-ray studies revealed the full structure of these enzymes, including their active sites. However, replicating their function remains a challenge. The active site is too fragile, and in natural holo-proteins, the apo-protein plays a crucial role as a shock absorber during multi-electron transfer. Even today, no one has successfully created a synthetic holo-protein that works like the natural one.

Addressing a mini-international symposium on bioinorganic chemistry at IIT Kanpur

With Prof. Achim Mueller on the discovery of giant spherical Keplerate

NOTES

By this time, I had started loving Nature's Chemistry in Action. What is it? It's basically looking at how nature carries out chemistry. Think about when you're traveling in a crowded bus. Sometimes, you catch the scent of someone's sweat, and it's surprisingly sweet. But right next to them, another person's sweat has a strong, unpleasant odor. I started to investigate this chemistry with fun and adventure like Sherlock Holmes. To summarize, Fish Odor Syndrome is a genetic disorder, and interestingly, its earliest mention can be found in the Hindu epic, the Mahabharata. The Mahabharata, narrated by Veda Vyas and written by Lord Ganesha, describes Veda Vyas's mother as a beautiful woman with a distinct fish-like odor. Because of this, she was named 'Matsya-Gandhya', which means 'fishy-smelling'. When a fish dies and stops breathing oxygen, the bacteria inside it use TMANO (trimethylamine-N-oxide) as an alternative electron acceptor for metabolism. They convert TMANO to trimethylamine. The latter gives the rotting dreadful smell. This smell tells us when the fish is bad. In human, fish odor syndrome (trimethylaminuria) is a genetic disorder. Monooxygenase enzyme catalyzes to oxidize trimethylamine (bad smelling) to TAMNO (odorless) to be excreted from the body. If such an enzyme is missing then the sweat of human smells awful. Intrigued by this, we set out to model the TMANO reductase enzyme and successfully replicated both its structure and function.

Our presentation of this work at international conferences initially received some dismissive reactions due to its connection with the Mahabharata. So, in our next international presentation, I incorporated William Shakespeare's The Tempest, quoting Trinculo's monologue: 'What have we here? A man or a fish? Dead or alive? A fish: he smells like a fish.". The western audience remained calm this time. Some second and third group transition metals found in abundance in sea water bothered us. Why so? What is their purpose to be present there in abundance though these are trace elements in the entire Earth? If one assumes sea is the origin of biomolecules then people reflect Oro's or Strecker's synthesis. Just one example: the creation of HCN continuously from one carbon and one nitrogen sources like aldehyde and hydroxylamine. If catalytically these are combined under sea water to produce deadly HCN, then it can be tamed to condense to form 'Adenine' an important ingredient of DNA or even for ATP. We found 2nd row transition metal, molybdenum, to act as 'an environmental catalyzer' to continuously produce HCN in aqueous environment to serve as the precursor of 'Adenine'.

Similarly, in the late 80's, a particular primitive life, belonging to the Archaean domain, was discovered in 'Black smoker', under deep sea. They survive in very hostile environments, like at 100 degrees centigrade and are 'Hyperthermophiles'. We hypothesized that there must be the involvement of kinetically inert 3rd row element, 'tungsten' which may act under high temperature. Considering their catalytic activities, we synthesized similar assemblies as we did with molybdenum for the 'mesophilic' sulfite oxidase presents in human. When the X-ray structure of the active site of the hyperthermofile, 'Pyrococus furiousus aldehyde ferredoxin oxido reducatase' was reported we were overjoyed to notice that we have synthesized its exact model based on our intuitive chemistry. Today, 'Hi-Fi' DNA for laboratory research is used from hyperthermobile of Archean domain which are closer in lineage to Eukaryan domain (human) than bacterial domain. Handling of these DNAs is easy as these are stable at room temperature and do not get de-natured readily as DNA from bacterial sources do. I could model these types of complex molecules. The joy of seeing your designed molecule—built atom by atom in the lab—function just like nature's version is unparalleled. That moment, when you realize you've replicated nature's work, is the ultimate reward of witnessing chemistry in action!

If you ask me, why I delved into biomimicking, it is because this field has so many possibilities! Understanding thermodynamics is one aspect and the kinetic mechanism is another. Let me provide you a crazy idea about chlorophyll. Almost everything is known about its role to fix carbon dioxide. But I was checking the frustration of Willstatter (the discoverer of fixing carbon dioxide by chlorophyll). He wanted to show that carbon dioxide does bind to magnesium in chlorophyll but he was unable to prove. It was hundred years ago. I thought, why not replicate this chemistry in a test tube and see if carbon dioxide truly binds to the magnesium center of chlorophyll—and if so, understand its advantage? We could create a synthetic porphyrin magnesium complex that binds bicarbonate to Mg center. The editor responded, agreeing that demonstrating carbon dioxide binding to the magnesium center helps explain how the redox chemistry of this porphyrin complex is facilitated to form radicals—essential for carbon dioxide fixation. However, it challenged us: how is this relevant in native Mg-chlorophyll? We freshly isolated and chromatographically purified Mg-chlorophyll. In a carbon dioxide environment, we observed a redox potential shift similar to what we had seen in our model Mg-porphyrin complex. To prove the binding of carbon dioxide on the Mg-center, we rigorously subjected our isolated Mg-chlorophyll to C13 NMR. The low abundance 13C isotope in natural carbon dioxide drove us for data acquisition for more than 24 hours. Finally, we smiled as we observed that in native chlorophyll, carbon dioxide indeed binds to the Mg-center. We published the entire study, dedicating our findings to the memory of Willstätter's discovery.

Today, researchers are engaged to reduce carbon dioxide for value added product. As back in 1992 we demonstrated that tungsten in +4 oxidation state is an avid oxo abstractor that abstract oxygen from carbon dioxide to form formate, a somewhat close to the reaction of the enzyme, 'formate dehydrogenase'. But these systems transform one molecule to another, converting a substrate into a product. The question is, can we use these proto-enzymes or synthetic enzymes for important transformations that we need every day? Can we use them to detoxify specific environment? All this could be used for our own purpose. In this way, this system can be a biocatalyst to be developed. These can do it repeatedly, at not much cost, and the pollution aspects would also be better. The potential is vast, we just need to harness it.

An example of such a catalyst is ‘acetylene hydratase’. In the pure ethylene industry, if crude ethylene contaminated with acetylene is passed through such molybdenum or tungsten-based catalyst in water, the pure ethylene can directly be used in the industry. The trapped acetylene will be catalytically hydrated to transform to form acetaldehyde which in turn can be oxidized to acetic acid. Another, interesting story we pursued is related to mosquito bite. Nitrophorins in insects like mosquitoes sequester nitric oxide (NO), produced by nitric oxide synthase (NOS), and store it in their salivary gland cells. We modeled nitrophorin to show how, at low pH, NO remains bound, but at blood pH, it is released as a vasodilator, expanding blood vessels to increase blood flow—helping the mosquito feed more efficiently. Once NO is released, the now-vacant nitrophorin binds to histamine, an immune response trigger, blocking the brain from sensing the irritation. Only after the mosquito has fed and left does free histamine become available again, signaling the damage and causing the swelling (edema) humans feel after a bite.

With biomimicry, I've demonstrated two aspects. One, you can get a newer category of catalysts for better, easier transformations with higher turnover to obtain important molecules. The other important aspect is how the molecules work. For enzyme reactions, the kinetics, is to be understood. Traditional chemical mechanisms, such as outer sphere (Marcus theory) and inner sphere (Taube mechanism), do not fully explain our work on atom transfer reactions. These reactions instead follow Michaelis-Menten kinetics, where the key step is the formation of an 'Enzyme-Substrate' (ES) complex as the reactive entity. Unlike Taube’s inner sphere mechanism, which does not account for an 'ES' state in the ground state, our findings suggest that this state forms temporarily in the excited state. Thus, the close looking enzymatic atom transfer reaction differs from Taube’s inner sphere kinetics. We tried to focus this difference but the reviewers objected each time to add this opinion.

Koshland, the renowned biochemist behind the induced fit theory, once wrote as the Editor of Science: 'If you discover something that challenges the existing paradigm and want to publish it, no one—including me—will accept it.' He suggested two alternatives: follow Newton’s path and publish a book like Principia Mathematica, rather than just a paper. Or, push your work in increments, small pieces, so the established views are not shocked all at once. I took the second option. With all this mimicry we published in bioinorganic chemistry, only in 2017, I finally published our complete mechanism in the line of Micheal-Menten complex in a chapter in a Royal Society book. It's published now. But for others to accept it, it will probably take a few more years. Someone will eventually grab it, maybe out of ego, thinking, "This fellow said something; let's try it". That's one aspect that will be recognized in time.

“Science, a poetic philosophy in understanding nature”

Another important work people will appreciate could be drug delivery to the brain. It's difficult due to the blood-brain barrier, which doesn't allow everything to cross. Current approaches often target specific pathways with dedicated molecules called receptors. They try to hook the drug to a receptor that can cross the barrier through a channel. But if you have 10,000 drugs, you need to find 10,000 receptors! Costly, time-consuming, and not always easy to create the drug-receptor bond. That's how pharmaceutical companies mostly work.

I have had a vision of ‘dabba’, a tiffin box. Like a Bombay dabbawalla box, it doesn't recognize what's inside – chapati, vegetables, chicken, dal anything. It's just a box. We designed a ‘nano-box’ made from ordinary coal or from burnt dry grasses that can swim the blood stream and cross the blood-brain barrier. You can put any combination of drugs inside. It doesn't require any specific receptor. It goes in, delivers the drugs. And the box can be excreted within 7 days, thus completely removed from the body, it doesn't stay there. These boxes are non-toxic and amphiphilic in nature. A beautiful nano carbon made box we’ve done, and proved its utility using with animal models. We've published and patented it. But the current pharmaceutical mindset is stuck on receptors for some reasons. They might take more time to realize the potential of what we've done. But I'd be happy when they do, because this is ultimate – a smart nano-box that can deliver any combination of drugs by closing and by opening as it.

In biomimicking, one of the biggest unsolved question? How nature fixes one molecule of molecular nitrogen to two ammonia molecules per second, simply, without needing a sophisticated rocket science laboratory? It happens in the open, on the roots of plants. Ammonia is crucial for DNA, protein, everything, that's the first step. This is still a great challenge in biomimicking. If we develop a successful synthetic model, we could replace the energy-intensive Haber-Bosch process for ammonia synthesis, helping to address global hunger. Sustainability and energy efficiency are indeed big words, and this will cover in extent.

I say research should be curiosity-driven. Today's work isn't always about fundamental things. Some questions, probably nobody can answer, even Hawking’s could not do that. You talk about the Big Bang, but what was before it started? " And, let there be light" in ‘Bible’ implies something before. Where from that high-density mass came from? Who created it? That's the same question as who is the absolute creator? Is it ‘He’ or not even ‘He’- one of the first questions in Rigveda raised thousands of years ago – still unanswered. That type of query you can think about. Another way is to think about what we need today, how research can make life better for so many people.

WAY TO GO

Innovation and motivation should be driven by need. Look at Haber, who did nitrogen fixation. He was initially thinking of extracting gold from seawater, which is vastly more abundant than all the gold mined. But the concentration was incredibly low. He made it a thousand times more concentrated. Then, his country needed explosives, not fertilizer. So, he used ammonia to make nitric oxide and then nitrates for explosives. So, research can be driven by need of the country. If you have time, why not try to seek gold from seawater? It's still an open question. If you see my work, it's diversified. Whenever I see something can be done, I do it. Why is there rust? What's that black soot in the AC duct or fan blade? I've done research on those and published papers. Even with the coronavirus, I had a simple way to tackle it. I have a diversified way of dealing with things in my humble way, with whatever facilities and money I had.

My path was not of rose petals; some setbacks are worth mentioning. We developed this nanocarbon technology to image living organisms. We showed we could image Drosophila melanogaster throughout its entire lifespan, from egg to adulthood, beautifully, while they were alive. Their DNA is 98% similar to ours and so used in developmental biology. I thought, can we make a bigger machine with higher resolution and use the same for humans? Nanocarbon is water-soluble and non-toxic, we proved that. So, inject a little, and then use a camera-like device to get internal images, like NMR or MRI, but low cost, nothing complex. I submitted the project to develop that machine. It was denied because I am a chemist, not a biologist! They never bothered to see the Drosophila paper and the protocol. Some committee members, close to the Prime Minister, said, "No, you are a chemist, you cannot do this". That was my greatest setback.

Second, I asked DST for funding at 74 year of my age with a project. They evaluated and turned it down. No mismatch in science, no reason given. Later, I found out they thought, "At 74, why does this crazy person want money for research? He gets a pension, he can sing, watch TV and read newspapers!". They denied maybe 50 lakhs I asked for. This prevented me from presenting my ongoing research work at conferences or buying things for experiments. Even today, I'm invited to conferences to present our latest unpublished research, conducted using borrowed facilities—but I often lack the funds for registration and travel. That's the problem, the greatest setback. No clear criteria, just a few people sitting and deciding ‘not good’.

I remember when I was on such committees, I objected when they tried to deny young scientists. I was chairman of the young scientist scheme in DST for 10 years. Many projects were rejected, but I argued that in a vast country like India, many remote areas still lack research facilities. Funding a project with 20–30 lakhs wouldn't strain the economy—it could actually boost scientific progress. Now, I feel great that many of them are very established professors performing good research. Similarly, in India—even in Kanpur—I unfortunately noticed a reluctance to accommodate students from socioeconomically disadvantaged backgrounds. They always want to pick students whose socioeconomic status is good. I remember a student from Bihar, a topper from Bihar University, who did well in the IIT Kanpur qualifying exam. But no one wanted to accept him—just because his father was a rickshaw puller… well, never mind. I opted for him. Some wise people said he wouldn't do great things, and I would face tough problems. I said, "But he is academically good!" And this is one example where I was right. The student earned his PhD, went to the U.S. for a postdoc, then returned to India. He received job offers from both Ranbaxy and a teaching position in Bihar.

However, there is still much to explore in the field of nature's action chemistry. Comparing countries like the USA, Germany, Japan, they emphasize innovation. They don't copy. Through innovative methods, they strive to make society happier with new discoveries that are accessible, achievable, and require minimal effort. Health is another aspect. Unfortunately, in India, we are still copying everything. That's a problem. You see a paper, and the first sentence goes: 'So-and-so has shown this, someone else has shown that, and now I am showing this too. From top to bottom, that's the research they do. Seldom are we the first to show something. And if you are, affluent countries might not publish your paper because you're claiming something new and big. That's how Raman and Bose were denied their respective first attempts for publications.

So, many PhDs do copy-paste, their publications are not in proper order. And when it comes to recruitment, local journal publications don't get much credit—they look for JACS, Angewandte Chemie, or Nature. Today, a Nature publication costs minimum 12 lakhs! And who are the editors? Young PhDs from there. It's not always about the institute. There's a bias. I can give a couple of examples from conferences in Europe and America. Someone would give a speech, and then a professor would be missing for a whole day and return the next. Other professors would investigate. They'd find that the missing professor was doing the same research but lagging behind. When he heard the presented work, he went to his hotel room, opens his laptop, and started pushing his students to get the same results within two days! This is sometimes backed by governments' intelligence, so they can claim the discovery first. Remember the classified documents gathered by US intelligence? They were passed to Professor G. Wilkinson at Harvard, revealing that Professor Fischer in Munich was working on a similar field—eventually leading to their joint Nobel Prize for 'Sandwich Complexes'. Sometimes it's subtle, delaying publications, for instance or you might be offered money to sell your idea. Nature can't possibly publish all the good research happening worldwide every week. You need the glory of the institute, the money, the backing of your country to get published there.

Our political scientists and these ministries need to seriously think about how they are going to contribute. Is CSIR comparable to Max Planck Institute? Not at all. Shanti Swarup Bhatnagar wanted to have CSIR institutes that were the idea. But we defaulted. Most the garbage is pushed there. That is because a lot of channels filled with those political scientists. In those days, anyone returning from Cambridge or Oxford—whether they had completed their research or not, often studying there on their parents' fortune—was still given recognition just for having been there. It is Cambridge lobby comprised of the good, the bad and the ugly. Mostly they hold good positions in the government. And used their thought like a blunt knife – it cannot make a sharp cut, like the Heisenberg uncertainty principle. They are not envious, but jealous. "Why should this person get this chance?" But it's not about chance; it's about stopping knowledge from reaching the community. They put a monkey wrench in the works, slow it down, and stop it. The middle persons are dangerous because they lack imagination. They don't have the will to do good. There's no dearth of good people in India to do good work, but they get demoralized.

I sometimes question if science and the fraternity are over the top complex? Then I realize -No, it's not complex, we are deliberately making it so. Real scientists never go for coveted positions or big titles. Albert Einstein refused to be president of Israel! Real scientists stay away from all that. But political scientists, we have a lot of them. They want to be there and make everything cloudy so people get confused. But science is simple, like music. It describes everything lucidly. There's no need for complexity, yet people complicate things for personal gain—something that needs to be addressed.

But, setting this apart, you know, Guru mil jata hai per sachha chelan nahi, if one sees from other side. I don't think I can give an English equivalent, it's very difficult. Today, those who want to pursue academics and research struggle to find an environment that truly encourages open thinking and exploration of nature and the universe. They don't find opportunities to interact with people who can inspire them. It should start very young. In this mobile age, people read so many things, but if it's academic, they refuse. But even if out of a thousand, two or five are inspired, that's enough. You have to give examples so they start searching, trying to find out. In India, people only talk about two or three scientists, Raman, and that's it.

In Germany, in a farming place, an old person asked where I was from. I said India. We were conversing, and then I mentioned Albert Einstein. They both smiled and said, "You know, we have so many that we don't remember". That's the answer I got. But here, a person unable to write his full name will keep asking about Raman. We are almost making Raman a Bhagwan, we worship now. So many Bhagwans in the making in India, that's the problem. Young minds should be introduced to thought-provoking topics in school curricula—things that encourage learning, questioning, and critical thinking. Someone can narrate, you can show examples. It's not only Raman. So many other people have contributed such as Srinivasa Ramanujan, Sir Jagadish Chandra Bose and Satyendra Nath Bose. Not everyone can be Raman, nor can he be a universal example, but many follow their own paths and make an impact. In that sense, we're proud and grateful to have started something—to show Indian and international students that we have many great scientists doing remarkable work. To mark my journey, I have narrated my time in science with a hope.