EDITORIAL

As we sail into the 8th year of our young institute, this newsletter aims to provide a common platform to bring together all the events associated with TIFRH, scientific and otherwise. In this inaugural issue, we bring to you an array of articles along with some creative titbits. We start off the issue with the cover story tracing the marvellous journey of TIFR Hyderabad, right from its conception to the point we stand today, a full-fledged institute bustling with research activities. We feature an article by Prof. Hari Dass, which will make you ponder about the no-cloning theorem in quantum mechanics and its implications, and Shubhadeep Pal, who gives an insight into the importance of reducing carbon emissions. We also feature an exclusive interview with the NMR bigwig, Prof. Shimon Vega, who talks about his foray into NMR, the long-standing relationship with his student, Prof. P.K Madhu, and dealing with hiccups in science. TIFR has a long history of outreach programs and other activities encouraging science education at the roots. At TIFR Hyderabad, we intend to continue this paradigm and to this end, Debashree Sengupta talks more about the active initiatives being taken in this direction. Moreover, amidst a variety of interdisciplinary research at TIFRH, we have highlighted a few in the ‘InFocus’ section of this issue. Lastly, in the non-science end of this issue, we present to you some comic relief, a poem about life and friendship in a research institute, and a photo gallery sporting a few talented shutterbugs at TIFR Hyderabad.

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If you would like to submit articles for the next issue of the newsletter or give your comments on any of the articles, please write to us at the newsletter@tifrh.res.in.

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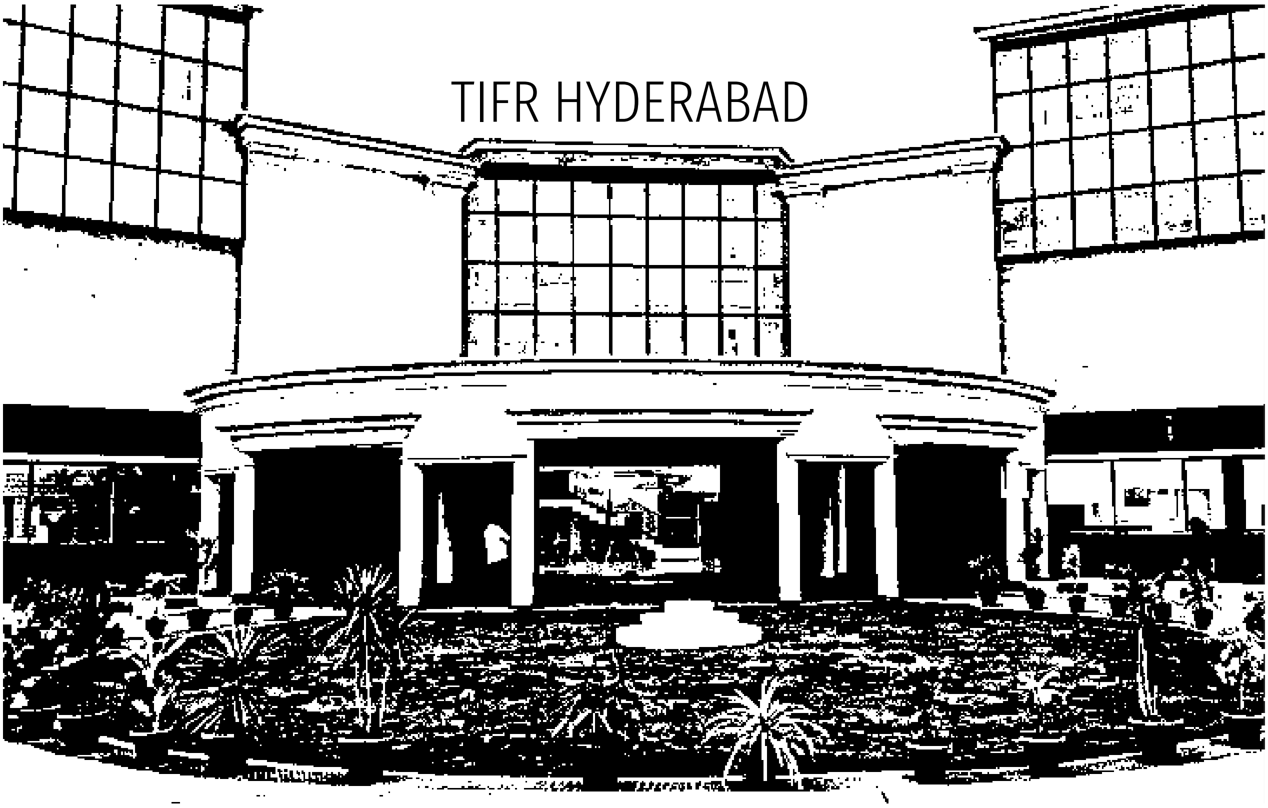


tracing the roots...

Anusheela Chatterjee
Science Writer, TIFR Hyderabad

“I shifted to TIFR Hyderabad literally lock, stock and barrel on April 2 (avoided April 1 deliberately!) 2012. Apart from the pleasant surprise of a ready-made Guest House in Aparna Sarovar E1002, there was not much on offer. Srikanth Sastry, who joined with me, promptly left again for JNCASR to put his stuff in order and make the transition in a more orderly fashion after a few months. At that point of time, I had three students in my group: Debabrata Sinha, who was already in Hyderabad before I joined, Chandana Mondal and Saswati Ganguly. I had asked Chandana and Saswati to stay back in Kolkata for a while because they were well ensconced in the hostel at IACS and because I had no idea of any hostel facilities at Hyderabad. There were none. The only thing that existed apart from E1002 was the building in Narsingi - without the partitions and offices. A big open space with just one office to be shared by whomsoever the occupants were. Debabrata made himself comfortable in a room on the terrace. And then we got Mumtaz as the official driver of an official car. In a few weeks, Narsimha joined as our first staff and P. S. Murthy came down from Colaba as our designated administrative officer. Of course, our Centre Director, Rajaram Nityananda, was around. Sriram, VC and Rama had not yet joined. Soon, we had a Centre of sorts with one building, one guest house, one centre director, one faculty, one student, one administrative officer, one staff and one driver. That was the beginning of TCIS.”

As Prof. Surajit Sengupta recollects his initial months at TIFR Hyderabad, one cannot help but marvel at how the institute has grown, in leaps and bounds, since 2012. With the institute still in its 'pre-teens', one is presented with a unique opportunity of listening to an interesting mix of people: those who have been associated with TIFR Hyderabad since it were just a concept on paper, those who still fondly recall the time spent in the transit campus at Narsingi, and those who have never tasted Amma's dosa and tomato chutney.

If you belong to the last category, this article will attempt to tell you a story. "A long time ago in a galaxy far, far away..."

When TIFR Hyderabad was just a concept on paper

Sometime in mid-2007, (it was probably raining buckets, given Mumbai's history of monsoons), Prof. Mustansir Barma recalls a particular meeting, with a few of his colleagues in Prof. Sabyasachi Bhattacharya's office. Prof. Bhattacharya was the director of TIFR Mumbai at that time. It was during this meeting that an idea of a new campus was being explored. Prof. Barma explains that the research in the new campus was envisioned to be rooted in basic sciences while it made inroads into the applied sciences. It was also envisaged that the research in this institute would address questions that would cut across multiple disciplines.

The major driving force behind the idea of an inter-disciplinary institute included Mustansir Barma, Sabyasachi Bhattacharya, K. V. R. Chary, P. K. Madhu, M. Krishnamurthy, B. J. Rao, Krishanu Ray, Shankar Ghosh, Kalobaran Maiti, Arvind Vengurlekar, N. Periasamy, R. V. Hosur, Sanjay Wategaonkar, Deepa Khushalani and S. Ramakrishnan. This idea slowly gained steam and by June 2008, possible sites for the new campus were being surveyed. While scouting for land, Talegaon and Taloja in Maharashtra featured on the list of plausible locations. Following an initial conversation with Prof. K. V. R. Chary, the then government of Andhra Pradesh invited TIFR to consider setting up the new campus in Hyderabad. In response to the invitation, TIFR presented a proposal to the government of Andhra Pradesh on October 15, 2008, requesting for an allocation of land for the new campus of TIFR. Within a month, an area of 209 acres was identified for the proposed campus. This land was barely a kilometre away from the rear gate of the University of Hyderabad campus. This presented a plethora of opportunities to collaborate with one of the most established central universities in the country. There was no looking back. It was decided that the new campus would be established in Hyderabad.

Inspection of the land in Hyderabad (2008)

Meanwhile in Colaba, a 'town hall' meeting was scheduled. Prof. Barma says, "This term was used to refer to a meeting of all faculty members in TIFR Mumbai. Such meetings are usually quite rare. During one such town hall meeting, I made the idea of a new campus known to the community. The response from the community was quite positive and prompted helpful inputs from all departments and centres. The TIFR Council, who immediately and strongly supported the idea, suggested that we put forward a 'concept paper' first."

Portions of the land that was allocated to TIFR for setting up a new campus in Hyderabad

Now, as all final year graduate students will agree, writing is not an easy task. The team from TIFR Mumbai sat down to write the 'concept paper'. This piece of writing would outline all the major goals, research themes, academic structure and an estimated strength of the workforce of the institute, along with projected outcomes over the course of several decades. This writing task was a joint effort by many individuals including Prof. Sabyasachi Bhattacharya, Prof. Mustansir Barma, Prof. Rajaram Nityananda, and Uma Mahadevan (an IAS officer). Once this task was completed, the 'concept paper' was presented to the TIFR Council. In the month of July 2010, this was approved by both the TIFR Council and the Atomic Energy Commission (AEC).

On October 19, 2010, the Prime Minister of India, Dr. Manmohan Singh, unveiled the foundation stone of the new campus.

Unveiling of the Foundation Stone

A bigger task lay ahead. Prof. P. K. Madhu says, "Later that year, sometime around November, two brainstorming sessions were held to plan for the initial academic focus areas at TIFR Hyderabad. One of these sessions was chaired by Prof. C.N.R. Rao (Member, Council of Management, TIFR) and the other by Dr. S. Banerjee (Chairman, AEC).

At the end of 2010, TIFR Center for Interdisciplinary Sciences (TCIS, the first centre of TIFR Hyderabad) was proposed and funding was allocated by the DAE for the infrastructural and research initiative."

This set the ball rolling.

‘O Transit Campus! My Transit Campus!’

The construction of the new campus would happen over a course of time. It was imperative to search for a potential temporary working space in order to begin research activities as soon as possible. By December 2010, ‘Plot No.21, Brundavan Colony’ at Gandipet was earmarked as the building where the research facilities would be set up, temporarily.

The transit building at Narsingi

Prof. V. Chandrasekhar describes his first visit to the transit building, “I came to the transit building, in 2011, along with Rajaram Nityananda. There was a building opening ceremony by breaking a pumpkin. My joining at TCIS was still a year away. The place was very remote; there was no human movement, forget about road traffic!”

Prof. Rajaram Nityananda was the first centre director. He was one of the first occupants of the transit campus when it had hardly any semblance to a research institute. Rumour has it that he used to cycle for around twelve kilometres from the University of Hyderabad to the transit campus and back, every single day. Eager to hear about his experience at TCIS and more so, to verify this urban legend, I reached out to Prof. Rajaram Nityananda over email. Turns out, every bit of it was true. Golly!

Prof. Nityananda narrates, “Vijayadasami, 2011: A festival often associated with beginning academic activities, and here I was with the biggest office of any Indian scientist, all 40,000 square feet of it, sitting in front of a computer, debugging a misbehaving programme. Herculean efforts from a large team in Colaba had created this project - the TIFR Centre for Interdisciplinary Sciences, and rented this building in Gandipet. University of Hyderabad had graciously provided boarding, lodging on its campus, an office with great company in the physics department and a dozen enthusiastic students for an astrophysics elective – so this phase was by no means as lonely as it sounds. The vast UoH campus and the verdant surroundings at Gandipet inspired me to buy and use a second hand bicycle. Talking of inspiration, I remember going to lunch in the buffet area of the University guest house and seeking the nearest chair, from which I saw the sprightly figure of C. R. Rao, legendary statistician and more than quarter of a century my senior, standing in animated discussion with his colleagues – I learnt he was revising his book on linear statistical inference!

The first pair of adventurous faculty and one student joined TCIS in April 2012, and my successor in June, and the rest is history. It was my privilege to hold the fort, however briefly. TCIS is now a flourishing fortress of interdisciplinary science, populated by both new entrants and some of the colleagues in Colaba, who worked so hard to make it happen.”

Prof. Rajaram Nityananda was succeeded by Prof. Sriram Ramaswamy. Despite the obvious difficulties which stared at the face of the researchers, the institute pushed itself to conduct research of the highest standards. Interestingly, an excerpt from Dr. Homi Bhabha’s speech during the stone laying ceremony of the buildings in TIFR Mumbai reads the following:

> "The foundation stone is being laid today 8½ years after the Institute was founded. This is perhaps not quite as it should happen — but to some extent it should, because the real thing that matters is the work that is done. I remember when the Institute was opened, the Chairman of the Council in his speech said, "We have not in the usual way waited for the completion of new buildings before commencing our research activities, but have, so to speak, plunged 'in medias res'. I regard this as a happy augury for the future because, in creative work of this kind, what matters most is the enthusiasm of those concerned with it."

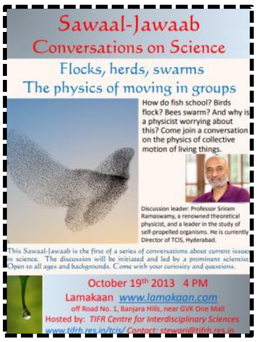
Prof. V. Chandrasekhar says, "In the initial weeks, we had no canteen. During this period, owners of the building supplied food to us. We organized a canteen which later got transformed into Amma's canteen. Mr. Srinivasan came down from TIFR Mumbai and helped us in partitioning the space and creating the labs, auditorium, and lecture halls."

By 2012, students had started trickling in and a robust graduate programme was designed to make sure that their foundations were strong. In the initial years, graduate programmes in physics and chemistry were introduced. The graduate programme in biology was initiated in 2015. The students had to complete the coursework in a designated amount of time. They had to choose from a wide variety of courses, both core and elective ones to fulfil their credit requirement. Students were encouraged to take courses from a range of disciplines, rather than restricting themselves to familiar turf. This helped foster the 'inter-disciplinary' outlook of the institute, right from the very beginning. The proximity to the University of Hyderabad campus promoted a steady exchange of knowledge. While some members of the TIFR faculty taught courses at the university, a few students took courses on Statistical Mechanics (2012), Dynamical Systems and Chaos (2013), and Cancer and Stem Cell biology (2015) at the university.

Graduate programme	Year when it was introduced
Physics	2012
Chemistry	2013
Biology	2015

In addition, the students were required to complete small-time projects in a few labs, mostly to zero in on a lab of their choice for pursuing their PhD. Most of the initial students were instrumental in setting up of the labs. In due course of time, the transit campus housed state-of-the art lasers, high performance computers and x-ray spectrometers. It was decided that a high field NMR facility would be built in the premises. Dr. G. Rajalakshmi narrates the first hiccup while installing the mammoth spectrometers, "The high-field NMR facility started with the arrival of the 700MHz NMR machine from Bruker, Switzerland in October 2015. The 1.2 tonne machine came to the transit campus at Narsingi and it was to be installed in the ground floor. The task of unloading the machine from the trunk and taking it to the ground floor, which was actually one level up from the road, was an adventure in itself. A crane had been hired to help us with the task but to our horror, when we tried to lift the wooden box with the NMR magnet off the truck, we noticed that the base of the box was falling off! The ingenious crane driver helped us safely get the magnet into the building and to its appointed location without any calamity. The experience prepared us well for future installations and the move from transit to the main campus."

The institute began considering opportunities for engaging with the people of Hyderabad. Lab tours for school students were a recurring event but there had to be some way in which



the scientists could interact with the general public, if possible on a regular basis. This led to the start of a science café called ‘Sawaal-Jawaab’ in Lamakaan, Hyderabad. This initiative was steered by Prof. Shubha Tewari. On October 19, 2013, the first ‘Sawaal-Jawaab’ session took place. Prof. Sriram Ramaswamy spoke about ‘Flocks, herds, swarms: The physics of moving in groups’ in a manner that was easily understandable by the layperson. This became a regular event and in some ways, marked the beginning of science outreach activities in TIFR Hyderabad.

Though their number was less, it never stopped the students from piecing together a vibrant campus life. The seating areas for the students were located on the third and fourth floors of the building. The students sat together, and were not grouped on the basis of their discipline, no pun intended. An experimental physicist sat in a room with a theoretical physicist, a biologist and a material scientist for company. Folklore goes that a group of students would crowd around one system and play a game of chess online. Each game had to bear the brunt of the combined intellectual onslaught of all the participants. Chess was not the only sports activity that students indulged in. Along with a night canteen, the roof harboured provisions for table tennis.

Prof. Sriram Ramaswamy stressed that along with research and teaching, it was important to “keep student morale up through excursions or pack everyone into the Winger to go to a movie”, he continues, “To cool off after our highly vocal faculty meetings we'd go down the road to eat amazing gelato at Sandwich-O. Sometimes we'd skip canteen lunch in favour of samosas at Pandeyji's stall across the road.” Till date, every student who has spent some time in the transit building fondly recalls their interactions with Prof. Sriram Ramaswamy and Prof. Rama Govindarajan. Both of them fostered a culture where students could easily approach faculty when faced with any problems.

Dr. Sharath Jose, a former graduate student, says, “On coming to TCIS back in 2012, Narsingi was far removed from the environs of IISc and JNC that I had become accustomed to over the preceding two years. The TCIS building was by the (then scenic) highway leading to Shankarpalli and a couple of kilometers from Narsingi village. The terrace offered a place to relax and reflect in the evenings as one gazes over the surroundings filled with thorny shrub. On moving a little away from the road, one comes across a dry riverbed where one can find goats and buffalos grazing. Flocks of peacocks were not an uncommon sight, with them offering spectacular scenes of flight during the Monsoons. The few that we were, we relished stepping out of TCIS as a group - for tea, going to Osman Sagar, getting into the city etc. Unorthodox place for a research institute - maybe! But it certainly served as a setting for lots of interesting memories.”

While research activities progressed in the transit campus, preparations were underway to relocate to the permanent campus at Gopanpally. The team which were working towards taking this project to completion had grown bigger- Dr. Jayant Kayarkar (Registrar of TIFR) made multiple trips to Hyderabad while Prof. R. G. Pillay and Prof. E. V. Sampathkumaran contributed to the detailed project and financial planning. Prof. Barma recalls that the faculty members had extensive discussions on the design of spaces in the new campus. An enormous amount of planning had gone into the design of unique student seating areas, presence of parallel service corridors behind the labs and an open space meant for discussions. Theorists will endorse this:

blackboards are necessary and this is non-negotiable. A father-son duo, local residents of Hyderabad, was entrusted with the responsibility of manufacturing the blackboards for the new campus. Prof. Barma later said, "Those were the finest blackboards that I have ever seen." Architectural plans for the First Research and Teaching Building (FReT-B) were drawn up by Anshu Gupta from the Directorate of Construction, Services and Estate Management, DAE. The construction of FReT-B began in July 2012.

Construction of FReT-B in progress

The shift to the permanent campus

There's no point denying this- the worst thing about shifting to a new house is the process of shifting itself. Packing off an entire research institute- lasers, spectrometers, heavy-duty microscopes, other lab equipment, furniture, students, faculty, staff et al. - to a new address was an enormous task. This shift began on June 28, 2017. By October 31, 2017, all the labs had been shifted to the big white building near Gopanpally Thanda.

A signage outside the transit building that announced the shift to the new campus.

Since then, the institute has seen a lot of changes, positive ones mostly. The left wing in the ground floor boasts of a National High-Field NMR facility with six spectrometers. The right wing on the same floor provides healthy competition by lodging a clean room with a high power 0.5 terawatt Ti:Sapphire laser. A molecular beam epitaxy chamber and scanning tunnelling microscope has been coming extremely handy in condensed matter physics experiments. A High Performance Computing Cluster sits pretty in one of the service buildings. There are five biology labs in the institute at present. With fully functional chemistry and biophysics labs, and spacious classrooms, the institute has been expanding steadily. The interactions with the University of Hyderabad have increased- be it regular Life Science and Chemistry seminars or science communication activities. The institute appeared on social media platforms and very soon became one of the 'Twitterati'. Additionally, it has full-fledged activities which are aimed at providing a boost to the science education in schools.

From one student to ninety five research scholars, from 40,000 square feet to 100, 000 square feet, from concept to a reality, TIFR Hyderabad has traversed one long journey. When one stands on the terrace of FReT-B, s/he is greeted by a huge expanse of land. The land shall soon house a world-class interdisciplinary research and teaching institute; and when that happens, it shall make another great story.

Acknowledgements:

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Ms. Roopashri Prasad and Ms. P. Hemalatha for providing with the dates of important events.


TIFR Hyderabad, 2019

Timeline of events

2008-2018

2008

- June, 2008: Survey of possible land for the new campus begins.
- November, 2008: TIFR signs Memorandum of Understanding (MoU) with the University of Hyderabad. for establishing its new campus in Hyderabad.

2009

2010

- July, 2010: The Director of TIFR Mumbai presents the 'concept paper'. The Atomic Energy Commission gives approval.
- October, 2010: The Prime Minister of India, Dr. Manmohan Singh, unveils the Foundation Stone of TIFR Hyderabad.
- December, 2010: 'Plot no. 21, Brundavan Colony' at Gandipet is identified as the transit building.

2011

- June, 2011: The transit campus becomes operational.

2012

- July, 2012: Construction of FReT-B begins.
- August, 2012: TCIS-TIFR introduces a graduate programme in physics.

2013

- July, 2013: The first TIFR Council Meeting takes place and Mr. Ratan inaugurates the chemistry lab.
- August, 2013: TCIS-TIFR introduces a graduate programme in chemistry.
- October 2013: Prof. Sriram Ramaswamy speaks at the first 'Sawaal-Jawaab' session of TIFR Hyderabad.

2014

2015

- August, 2015: TCIS-TIFR introduces a graduate programme in biology.

2016

2017

- June 2017: The shift to the new campus at Gopanpally begins.
- October 2017: All labs shift to the new campus.

2018

Quantum Dolly is an Impossibility!

Prof. N. D. Hari Dass
Visiting faculty, TIFR Hyderabad

Image: An example of classical copying in nature is the Giant Causeway in Northern Ireland, an area of about 38,000 interlocking basalt columns, the result of a volcanic eruption 60 million years ago. (By geolman, Source: http://www.geodiversite.net/media543, http://www.geodiversite.net/auteur5)

Why talk of a Dolly in the quantum context? Dolly, the sheep, was a clone. Clones are supposed to be perfect copies of their original. In the case of Dolly, the original is a living entity, hence all the excitement! In the non-living context, we are familiar with a Xerox Machine. An ideal Xerox machine would make perfect copies of the original. It can also make an arbitrary number of copies. So, what is the big deal, you might ask. The big deal is that in the quantum world, such copying is in general, impossible! This is a very deep result that sets the quantum world in deep contrast from its classical counterpart. To appreciate the significance of it requires a careful dissection of the classical and quantum world. As of today, the scientific consensus is that our world is governed by quantum mechanics. What then do we mean by a classical world? The point is that in an approximation to the quantum world one obtains the so-called classical world which seems to govern pretty much most of the macroscopic world around us. But the laws governing such a macroscopic world were discovered first, for obvious reasons, and this is what one means by the classical world. That world, which included such magnificent creations like Galileo's inertia, Newton's laws, Maxwell's electrodynamics, and even Einstein's special theory of relativity, went a long way in accounting for the world around us. Important to the dissection we wish to undertake is a clear delineation of the structures of the two theories. All theories start with the primitive notion of states. In classical mechanics, the state of a point particle is specified by its position and its momentum at the same instant. The other aspect of theories is Dynamics. This is the prescription by which given the state of a system at one instant one can uniquely determine the state at a later instant. In classical mechanics, this dynamics is described by Newton's laws. For the purposes of this article, the detailed form of these laws is not very relevant; nor is it important that these dynamical laws can be recast in vastly different (but physically equivalent) forms like Lagrangian or Hamiltonian forms. When there are many different particles, the state of the composite system, in classical theory, can be construed from the states of the constituents. A concept crucial to our subject of focus is that of measurements.

In classical physics, there are two central aspects to be remembered i) no separate laws other than the dynamical principles are needed to describe measurements, ii) there are certainly errors but these can be controlled and compensated with the consequence that measurements do not affect the state of the system measured. For classical copying, this leads to another subtle aspect; a perfect Xerox machine can make perfect copies whether or not the state (in this case the document being copied) is known before hand or not. You may be puzzled as to why this apparently irrelevant detail has been brought in! You will appreciate this when we turn to quantum theory later on. You may even wonder what exactly it means for the copier to know the document beforehand! Think of the machine as a general purpose one which can print and scan. Usually, in Xeroxing, the document is scanned and then printed. First, think of a machine which can take an input file and make copies of its contents. This is what we would call perfect copying of a known state.

Now, consider feeding to the machine for which no such input file has been provided. We call that copying of an unknown state. In the classical context, as we know too well, this hardly makes any difference. In the unknown state case, the machine scans the unknown document and then prints or copies it as a known document. Crucial to this is the possibility, both in principle and nearly always in practice, of scanning without mutilating the document. You may be wondering what all this rambling about Xerox machines has to do with differences between classical and quantum world. A most dramatic difference between them comes from the role of measurements in them. The scanning we alluded to is, in fact, a measurement. As already emphasized, in principle, measurements in classical physics

Image: A close-up of Dolly in her stuffed form. (By Toni Barros from São Paulo, Brazil, Source: flickr.com)

need not affect the state of the system and hence, even if a state is unknown, such a measurement can be made to know it fully without distorting it and that knowledge can be used to make perfect copies. It is here that fundamental and dramatic differences arise between quantum and classical theories. It is instructive to recall the meaning of states in quantum theory and though a full elucidation requires technicalities, I will try to give a flavour of it which is as faithful to the precise characterization as is possible in a verbal account like this. In the classical case, the state of a particle was specified by all the components of its position as well as by all components of its momentum. A measurement of these quantities will return precisely these values and the state after the measurement is the same before. In fact, one can measure any property of the system, like for example, all the three components of its angular momentum or for that matter, all components of its Runge-Lenz vector etc. The point is all these are functions on phase space which is the space of states of a classical theory. In effect, all this results in a deterministic description. It is difficult to give such a linear narrative in quantum theory. Heisenberg's matrix mechanics is somewhat better suited for this even though Schrödinger's wave mechanics is a physically equivalent description of the quantum theory. Both these were completed in 1925. According to Heisenberg, the observables of classical theory like momentum and position were now to be treated as not only operators but non-commuting operators. If you feel uncomfortable with what operators are, think of them as matrices. A natural question that arises is about the value of an operator or if you so wish, the value of a matrix. A matrix has rows and columns of numbers, complex in the most general case. Which of these is the value of the matrix? Are any of them the value of the matrix?

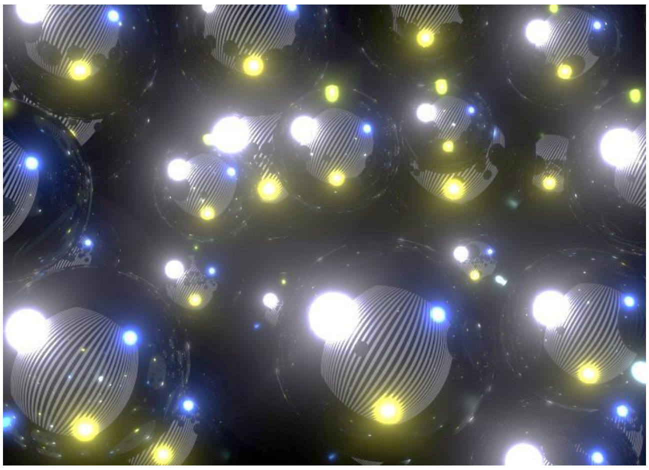

Image: An artistic imagination of the microscopic quantum world of atoms and molecules

Mathematically speaking, none of these rows and columns of numbers gives an intrinsic characterization of the matrix as they depend on the basis chosen for representing the matrix. The situation is exactly analogous to that of the components of a vector which can always be changed by choosing different basis vectors, without changing the vector itself. Mathematically speaking, one can attach values to an operator (matrix)! These are the so-called eigenvalues! So, can these eigenvalues be taken as the values of the physical observables which are to be taken as operators in quantum theory? Recall that in classical theory too, the values of observables depend on the states in which they are observed. So if eigenvalues are to be taken as values of observables in quantum theory, what are the corresponding states? Taking a cue from the Matrix theory, one would say the eigenstates of the operator in question. This line of reasoning was adopted by Heisenberg for the Hamiltonian or energy operator, and extended to all observables by Dirac. It is important to add here that for the eigenvalues of physical observables to be real as would be required by the reality of values of physical observables, the corresponding matrices have to be Hermitian. With these preliminaries, we can raise more pointed questions about quantum measurements. So, it is reasonable to surmise that if an observable is measured in one of its eigenstates then the outcome is the corresponding eigenvalue. But does such a measurement affect the state? In the absence of any clear guidelines, let us see if what happens in the classical case is a possibility. Therefore for every state, the act of ideal measurement did not affect the state. In the quantum case, there is no reason why that should be so. But let us see what happens if we require this to be so for eigenstates only. We see that the rule is at least self-consistent in the following sense: if we perform the same measurement again, we get the same eigenvalue we got before and the state after the measurement is again the same eigenstate. That alone is not enough to validate this as a rule. But the great mathematician- physicist von Neumann showed in more technically convincing fashion this type of measurement is indeed permissible in quantum theory. Now comes the real crunch! If you take two 2x2 non-commuting Hermitian matrices A, B (simplest possibility) and look at their eigenstates (you can take any two of the so-called Pauli matrices), you will find that the eigenstates of the first matrix are linear combinations of the eigenstates of the second. Let us consider one of the eigenstates of the A matrix, with eigenvalue, say, a1; then this will be found to be a linear combination of the eigenstates of B, with eigenvalues, b1 and b2. As per the interpretation proposed just now, the eigenstate of A with eigenvalue a1 is a physical state in quantum theory and if we measure the observable A we will get a1. At the same time, this is a linear combination of the eigenstates of B with eigenvalues b1, b2 (which are not equal). But each of these eigenstates of B is also a physical state in quantum theory by the same logic. Putting all this together, one comes to a dramatic conclusion! This is the Principle of Superposition of States.

In the present context, the physical state |a1> (this is the modern notation to denote a vector in the so-called Hilbert Space) which has the definite value a1 for the observable A, is a linear superposition of physical states |b1>, |b2>, which however have definite values b1, b2 for the observable B. Note carefully that the latter two states have no definite values for the observable A! I wish to clarify a somewhat technical point to avoid misunderstandings at this stage. Actually, physical states are not represented by the vectors like |c> in Hilbert space; they are actually represented by so-called rays in Hilbert space. This means two vectors in Hilbert space differing by a phase factor represent the same physical state.

I want to strongly emphasize that you may have heard of superposition principles in many other contexts, for example, superposition of vectors in vector algebra, of sound waves, of electromagnetic waves etc. This superposition principle in quantum mechanics is like nothing you have heard before! To appreciate, let us enquire what outcomes of different measurements will be on |a1>. If we measure A, our rulebook so far says that the outcome will definitely be a1 and the state after the measurement is the same as the state before. So far, so good! Next, instead of measuring A on |a1> let us imagine measuring B on it. What will the outcome be? Not only is the state in question not an eigenstate of B, it is actually a superposition of two eigenstates of B with mutually exclusive eigenvalues! The rule book that we had does not say clearly what the outcome would be! But every measurement must have an outcome, else it is not a measurement! This impasse was resolved by a daring interpretation proposed by Max Born - called the probability interpretation of quantum mechanics. It is this that makes the classical world dramatically different from the quantum world; which in effect renders the quantum dolly an impossibility! So this interpretation says, if you measure B on |a1>, the outcome will be either b1 or b2, but in an unpredictable way! In other words, the outcomes of the measurement have definite values but the values are realized randomly! What is not random, however, is the probability of occurrence of these values, which is determined by the quantum state |a1> in this case.

Let us dig a little deeper into this, but before that, it should already be obvious that this superposition principle is of a fundamentally different character than all the other superposition principles we have encountered before in physics and mathematics. It is for this reason that we have to emphasize the term states in enunciating this principle. The fact that the outcomes are in themselves random but nevertheless with well-defined probabilities brings another important aspect of quantum mechanics to the fore. It is therefore clear that with only one measurement the outcome, being pure, cannot yield any information and hence no physical significance can be attached to the measurement. But in a realistic measurement in classical physics too, the outcome of a measurement has a random element to it resulting in the so-called statistical errors.

In classical physics, either the state is unaffected or affected in a controllable manner, one could have repeated the measurement on the same copy of the system a large number of times and reduce the statistical errors. Let us see why this luxury is not available in quantum mechanics! Though the outcomes are the eigenvalues of B randomly, consistency would require that if one performed a B-measurement on the state after the first measurement, one should get the same outcome as in the previous step. This is sometimes called the repeatability hypothesis. If we invoke this, the picture that emerges is that not only the outcome is an eigenvalue randomly; the state after that measurement outcome must become the corresponding eigenstate. This means quantum measurements, at least of this type, lead to a dramatic and irretrievable change of state. This is also sometimes called wave function collapse. This immediately makes a repeated measurement of this type on the same copy of the system useless. As this is a very important point, let us go over it carefully. Suppose we start with some state |X> and measure B with the aim of getting some information about it. Let us assume we are provided only one copy of the state. According to what we have said so far, the state we started with must collapse to |b1> if the outcome is the eigenvalue b1. With this single copy measurement we have lost all information about the starting state as the final state is |b1> which knows nothing about the initial state, nor does the eigenvalue b1 have any information about the initial state either! It is only a large number of independent measurements on an equally large number of identically prepared copies of the initial state that we can ever hope to learn about the initial state. For then, we can measure the probabilities of various outcomes and that indeed contains information about the initial state. These are called ensemble measurements.

At this point, it is worth pointing out that since this formulation of quantum measurements from the early days, explicitly realized by the von Neumann model, a wide variety of new schemes for quantum measurements have come up notably the so-called weak measurements and weak value measurements, quantum non-demolition measurements etc. But none them can really avoid the inevitability of ensemble measurements.

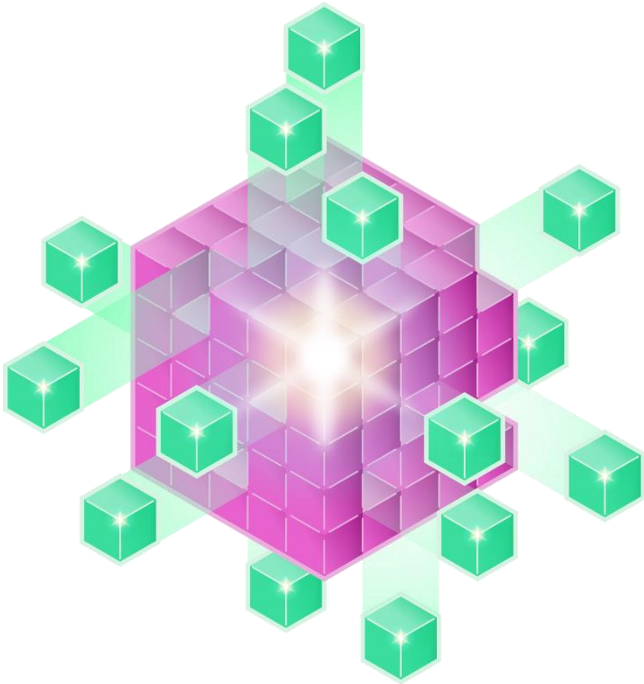

Image: An artist's impression of the impossible cloning in action. Here, quantum states are represented by small cubes.

After this long, but essential elucidation of quantum mechanics, we are now in a position to address the main concern of this article, namely, the impossibility of a quantum Dolly! I picked Dolly to dramatize the issue but for the quantum context that may not be the best choice. For one thing, Dolly's case involved the cloning of a living being (in fact much of the excitement was on that front!), and living beings are very complex. Also, the question of whether the original was a known state or unknown state is also moot. One can always argue that DNA and the genetic code make every living being a known state. Whether the original in the case of Dolly is a single copy or many copies is also moot as in the body of the original there are numerous identical copies of cells and their genetic material. So we shall play it safe and rephrase the impossibility we started with for the case of quantum states. Once again, if the quantum state is known, cloning or making an arbitrary number of copies is no big deal and works in spirit exactly as in the classical case. Again, if a large enough ensemble of identically prepared states is given, there is no big deal either. One can make ensemble measurements to determine the state (called tomography) and then use the knowledge of the state to make an arbitrary number of copies. The impossibility statement, also called the no-cloning theorem, states that it is impossible to clone or make multiple perfect copies of a single copy of an unknown quantum state. Since only a single copy is available, no measurement scheme can be used to determine that state (though we only showed how it works for Von Neumann projective measurements, one can show this for every type of quantum measurement conceivable). Thus, the analog of scanning in the classical Xerox machine will not work. While we have heavily used ideas pertaining to quantum measurements to argue the case, the theorem as originally proved by Wootters and Dieks, only used the rules for quantum evolution (dynamics) to prove it. The proof is so elegant and straightforward, that I will include its essentials here. Suppose we want to clone an unknown quantum state $|u\rangle$ into two identical copies. The way to do it is to consider $|u\rangle$ along with a blank $|0\rangle$ (think of this as the empty sheets of a classical Xerox machine. Now let the quantum dynamical process be described by a unitary transformation U (all quantum evolutions are described by unitary transformations, these are the technical aspects that you have to learn if you want to get a proper understanding of quantum mechanics). This means we have the cloning transformation expressed by the equation $U|u\rangle|0\rangle = |u\rangle|u\rangle$. Since the original state is unknown, the same U should clone any state! Therefore, if $|v\rangle$ is another state, one would have $U|v\rangle|0\rangle = |v\rangle|v\rangle$. Unitary transformations maintain the inner product between two vectors (this is exactly like rotations maintaining angles). This immediately gives $\langle v|u\rangle=\langle v|u\rangle\langle v|u\rangle$ which is only possible if $\langle v|u\rangle=0$ or 1. But $|u\rangle$, $|v\rangle$ were arbitrary, so the only way out is that no such cloning transformation U can exist. Though this proof makes no reference to quantum measurements, there is a peculiar inner consistency in the following sense. Suppose such universal cloning machines could exist (by universal, we mean that U is the same for all input states), then using such a cloning machine, we can produce an arbitrarily large number of copies of the unknown state. Using them, we can make ensemble measurements to determine the state! But this goes against the crux of quantum mechanics we stated earlier, namely, no measurements on a single copy can yield any information about it. Therefore, there cannot be such universal cloning machines. I end this article with a point that often confuses people when first confronted with the no-cloning theorem. They cite the laser as a possible counter example. In a laser starting with an initial photon injected into a cavity with population inversion, induced emission creates a huge number of copies of the initial photon. Superficially, it looks like the initial photon has been cloned and the no- cloning theorem has been violated! In a sense, the laser is a cloner, but it clones a known state as the lasing device has to be specifically chosen to match the initial state of the photon.

This article was previously published in the December- February issue of the Scienceteen Magazine. About the magazine: "We noticed that in India there is a requirement of science magazine which is easily accessible and understandable for the teens. We decided on this magazine four years ago and after so much research and the combined efforts of The Mathematical Way Institute and Ramanujan Shodh Sansthan, the idea could be framed. We hope the magazine, that we have been able to put together, gives a new direction to Indian teens and Indian Science education. We want to emphasize that our efforts will give a direction to a policy free science, so that anyone could easily pursue it." - Rahul Aggrawal, Associate Editor of the Scienceteen Magazine. Link: http://scienceteen.com/category/magazine/

Illustration: Shubhadeep and Anugraha

Reduce the CO_2: Here's to a better future!

Shubhadeep Pal
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In the 21st century, we can see that the usage of energy sources like petrol, diesel, coal, and LPG is growing tremendously- day by day- for our transport, food processing, daily work etc. While their utility is unquestionable, they produce huge amounts of gases like Carbon dioxide (CO_2) as a major byproduct. CO_2 is a well-known greenhouse gas that absorbs visible light and radiates heat energy. The amounts of such gases have only seen a monotonic increase over the years. Thus, it leads to capturing huge amounts of heat energy from sunlight and boosts global average temperature. Today, our planet is at an alarming stage and if immediate action is not taken, the results will be disastrous.

Climate scientists have named these catastrophic changes as 'Climate Change' and sometimes 'Global Warming'. This rise of temperature is also drastically melting polar ice sheets and these sudden changes can also result in increased incidences of natural calamities like tsunamis, floods etc. that can devastate our flora and fauna. This is a big risk and may threaten the existence of human civilization in the near future. Scientists from all over the world have been trying to find a way to overcome all these issues. Prof. Andrew Bocarsly from Princeton University, for example, has pioneered the establishment of a company 'Liquid Light' to reduce CO_2 into liquid products particularly and preferably formic acid, to additionally overcome our oil dependency. Coca Cola (KO) has joined hands with 'Liquid Light' to accelerate their technology towards commercialization. Multiple ventures with similar goals have sprung up, four of which are: DyeCoo, Newlight Technologies, Novomer, and Skyonic. They too are striving to capture CO_2 and convert it into chemicals, plastics etc. CO_2 and carbon monoxide (CO) are essential sources for sustainable polymer synthesis which in turn may be used to improve coating technology, adhesives, sealants and elastomers. Recently, we have developed a carbon-based catalyst to convert CO_2 into valuable products like formic acid (J. Phys. Chem. C, 2018, 122 (41), pp 23385–23392), and charge transfer mechanism.

Two scientists, William D. Nordhaus and Paul M. Romar were awarded the Nobel Prize in Economics (2018) for their work on the effects of technological innovation and climate change on long term sustainable economic growth in the near future. The press release of the Royal Swedish Academy of Science stated, "At its heart, economics deals with the management of scarce resources. Nature dictates the main constraints on economic growth and our knowledge determines how well we deal with these constraints." Even though scientists are trying very hard to find ways to ameliorate these effects, we should also bear a few crucial responsibilities of protecting our earth. Wynes, an environmental scientist, says that, we must obey four rules namely, having fewer children, living without a car, avoiding transatlantic flights, and eating a plant-based (mostly vegetarian) diet. A constitutional climate lawsuit filed against the U.S., known as "Juliana vs U.S.", argues that not acting against climate change is equivalent to violating the constitutional rights to life, liberty and property of future generations. Christiana Figueres thus concluded, "There will always be those who hide their heads in the sand and ignore the global risks of climate change. But there are many more of us committed to overcoming this inertia. Let us stay optimistic and act boldly together."

Science education and outreach at TIFRH: Small initiatives for a bigger change

Debashree Sengupta
Project Scientific Officer, TIFR Hyderabad

What do people do during a Ph. D. and what is the meaning of research? - a young girl curiously asked her teacher. I am not sure about the immediate answer she received, but let's ponder upon this question for some time. Apparently, there seem to be two separate realms on earth, when we consider advanced technologies, inventions and breakthrough research initiatives as one sphere, and the non-scientific general public including school-going young children as the other sphere. These two spheres connect sporadically with each other through science curriculum and textbooks, but then, are these connections enough for bridging the gap between high end research and community awareness? Certainly not! Science education and outreach is the enterprise that works for dispersing the concentrated scientific knowledge from the restricted spheres of Research institutes and universities to the general community and the school-going children.

At TIFR Hyderabad, there are two major initiatives taken under Science education and outreach program, with a future ambition to bring about significant change in the scientific temperament of the society. The first one is the 1) Deep learning initiative, which includes 3 sub-events taken up with schools of the Telangana Social Welfare Residential Educational Institutions Society (TSWREIS): a) Foldscope mission, wherein we trained teachers and students from 10 different TSWREIS schools, for using foldscopes (low-cost paper microscopes designed by Prakash Lab at Stanford University) for their regular Science curriculum as well as for project purposes. This initiative encouraged students to actively participate in a lab practical by getting hands on experience of using a microscope. Two workshops were conducted for helping the teachers to clarify their doubts, as well as troubleshoot the common issues faced during the usage of foldscope. As the tagline for foldscope goes, these young students along with their teachers are 'magnifying their curiosities' consistently, by posting their observations at https://microcosmos.foldscope.com/?tag=tswreis. Volunteers of the program post their observations at https://microcosmos.foldscope.com/?author=1733. The next sub-event is the b) Saturday outreach, which is a continuous effort by the TCIS and UoH volunteers, to build up a strong concept-based learning scenario among the young students and replace the traditional text-based rote learning. Under this program, volunteers visit three nearby TSWREIS schools every Saturday and teach subjects of their choice, particularly Science and Mathematics, but occasionally include English and Social Studies. Under concept-based learning, we also encourage children to open up their minds for critical thinking and questioning attitudes. It was surprising to find the array of questions bubbling up from these young minds, during our interaction with these students. The final one is the *c) Meet a Scientist event*, which involves direct face to face interaction of school students with eminent scientists from reputed research institutes and universities of India. Students get a chance to know the world of cutting edge research through this event and are free to ask questions and clarify their doubts/misconceptions, regarding various natural phenomena and day to day observations scientifically.

The other major initiative is the ***2) 'Sawaliram' project***, which is collaborative between TCIS and Eklavya (an NGO located in Madhya Pradesh) and has been inspired by the students' questioning during 'Deep Learning' sessions. As a part of this project, an open source, multi-lingual, web-based repository of students' questions is proposed. This repository is meant for encouraging and highlighting the questions from students belonging to marginalized sections of the society, who do not have access to facilities like computer or internet. So, there are multiple lines of workforce involved in this project starting from the core members, who are involved in building up and maintenance of the website, inputting and curating the data, analyzing the data and also coming out with user friendly interpretations of the analyzed data outputs. The expectation is to have a team of experts for answering the questions and another team for communicating the answers to the respective schools or groups as part of ongoing programs. This project aims to bring out the often neglected '*child's voice*' to a broader perspective of curriculum designing and policy making along with encouraging children to learn conceptually by confidently asking questions to fuel as well as satisfy their curiosities.

P. Ajith interacts with students during a 'Meet-a-Scientist' session

As a whole, these small initiatives taken up by TIFRH's Science education and outreach team revolve around the common goal of bridging the gap between the isolated scientific innovations and the non-scientific communities to build up a strong concept-based scientific foundation for the young intellects of our society.

"Shimon Vega, noted for some of the most insightful research in the area of magnetic resonance, both electron and nuclear magnetic resonance (NMR), has influenced professionally and to some extent personally the lives of many who have come in contact with him. This could be in the form of graduate students, post-doctoral fellows, colleagues, course students, or listeners to one of his great talks packed with science, wit, and active involvement. His enthusiasm has been often contagious and his understanding deep enough to compel chairmen of his talk sessions to give him enough time after regular sessions to explain to the particular conference audience nuances of his theoretical ideas. These are always done with deep flair to packed audiences. Shimon is indeed one of those rare combinations of openness to new ideas, but with a deep rooted knowledge on sound, pen-and-paper principles than going after the pursuits of transient fashions. He belongs to that genre with a great willingness to share his knowledge with others and being a restless researcher ready to question the so-called established paradigms. His inquisitiveness has always motivated his colleagues taking the respective research to even higher levels. Of the many contributions Shimon has made, some of them to highlight are in the magic-angle spinning experiments in solid-state NMR, breaking the barrier into understanding quadrupolar spins, introducing Floquet theory to understanding and developing various experiments and improving resolution and sensitivity of solid-state NMR experiments, and in the last few years providing insights into the important field of dynamic nuclear polarisation in NMR.

Shimon, originally from the Netherlands, moved to Israel for his PhD in the Weizmann Institute of Science where he became and is a faculty member after a post-doctoral stint in Berkeley. He has been to TIFR and TIFR-organised meetings in India a few times."

– Prof. P. K. Madhu, who was a postdoctoral fellow in Prof. Shimon Vega's group.

Prof. Shimon Vega attended the 'NMR Meets Biology' meeting at Khajuraho (India) in December, 2018. During this meeting, he had generously given us an interview.

Anusheela: Since some of the readers may not be very familiar with your area of research, could you please explain what you work on, in very simple way?

Shimon: Okay, Let me start (by) thanking you for today. Magnetic Resonance is a field which has enormous impact on many many aspects of exact sciences. By exact sciences, I mean Chemistry, Biology and also Physics. In the spectrum of the subject, the direction where my interest is that is the methodology and understanding of the spectroscopy. And that has an effect, during the years I was always on the boundary of doing experiments, explaining them or developing techniques or thinking about applications but eventually not doing them myself. So, that is the way it came out, and that is not which I planned before. Therefore when somebody asks me what I do, I generally give an answer which has nothing to do with my work. That is the only way to solve it, because you know I cannot talk about basic quantum mechanics to somebody. What happens nowadays, if somebody doesn't know me I say do you have any idea what MRI is and then you let it flow by saying there is something there which you see, which is very hard to explain. And I am working on to understand how that works. It's a little bit of a trick, because if I say too much people start asking questions and I don't know how to answer them. Or I make mistakes, that's also a possibility. Therefore, I always try to talk about the more general way about the things what I am doing, than what I am eventually doing, because even in the field of NMR itself, many many people don't understand what I am doing. And I have realised it, so you have a niche insight in this big field that helps. So the fact that I cannot give an example of that I saved a person, or I saved a chemical problem. I did some applications but not really as a long term project. And even at the moment I am working on a field which is very very popular in magnetic resonance as DNP. But also there I am not doing the nice things, I am trying to understand what kind of tools they use to get the results and that is sometimes frustrating.

Anusheela: But I think that's how fundamental science works, right? In basic sciences, you do not have a direct application exactly at that moment itself, but who knows?

Shimon: Yeah, and you create a language also, I mean I am not saying in my case (and) perhaps that's not a very good example to talk about myself, but you create the way. How are you allowed to think about the way you understand something? And that happened many times, that people have concepts, which sometimes are not according to the theory, but they become the language of the field. Unfortunately or fortunately that's what has happened each time.

Anusheela: Have you faced a challenge in convincing anyone who may think that this is probably not that important?

Shimon: In that particular case, it is a little bit more than this, because you know that without basic understanding there wouldn't be any NMR, and now people have so many possible applications, you think you don't need it anymore. You also meet students who don't realize that you should know the basics. Coming to the DNP (Dynamic Nuclear Polarisation), I sometimes quote myself which is not what I should really do, is that I realise that some concepts of the DNP are wrong, but they created the field. And then you realize later that the concepts are different, but in the meantime the field is flourishing. So, you should give an enormous amount of credit to the people who have an intuition and that is something which I really appreciate. Sometimes you talk to people and you really understand that they don't understand the way I understand it. But they push the field forward, not 20 people doing it. So you have to know your place, sometimes people don't have the patience for the more fundamental stuff but you know, in the work we did with Madhu, it always came down to writing equations, trying to understand what the effects are. But then he does amyloids, and I don't know what an amyloid is.

I have a problem with oversimplification, which is my personal take. But you also have to be practical, you cannot expect from people who really understand amyloids and know what it means to get an illness from it to know what a Hamiltonian is, they might not, they cannot.

Anusheela: Switching the track a little bit, how did you know this field was the one? How did you get into this journey of becoming a scientist?

Shimon: It goes back to high school. When do you decide the direction in which to go, you (consider that you) have to have a job, you have to do something, after high school. In my case, I was so bad in languages but reasonably good in physics and mathematics that I decided to study physics. I realised that it was a choice, because I was just stupid for other things. So that is that. Then I studied basic physics and mathematics, and then after my physics degree, I had to decide the direction in solid state physics, and then something happened. My brother was five years older and he was one of the students who worked in EPR those days, when NMR didn't exist. He was so excited about it, because it was a combination of spectroscopy and experiments and theory that I just got affected by him and I got into a group which was doing NMR. (The time that) I am talking about is in 1960's. So I did my masters working in solid state NMR, in antiferromagnets.

You are in the field, and it goes on. I did my Ph.D. in the end of 1960's, in 1970's I was looking for a place. Based on my personal environment, since I am a religious Jew, I tried to find a place to do my Ph.D. in Holland. I grew up in Holland. It was a very bad time. Phillips had a beautiful physics lab and then they closed down. So then my wife and I, I was already married at that time, tried to see what's happening in Israel. And that was very successful, I was accepted in a hallway by meeting somebody I didn't know, in NMR and that's the way I decided to go to the Weizmann Institute. Professor Lewis, whom I met in the hallway, asked, “What are you looking for?” I told him that I was looking for someone to talk to, who wants to take me as a Ph.D. student. He said, “What is your interest?”, and I told that I am doing NMR. Perhaps after 10 minutes he said, “If you come back with your wife I have a job for you.” Then, I did my Ph.D. with him. I also interviewed with other people and I didn't know (that) I will end up in NMR, but he was the person, one of the most marvellous people that I have met in my life.

Anusheela: You have been involved in NMR for a really long time, and NMR research started not too long ago in India. What is your take on how the field has evolved in India?

Shimon: For me, at least what I knew about NMR community in India, it was only Anil Kumar. I didn't know about much about the Indian scenario in NMR until Madhu joined me. It's not totally true. Before, I knew what was going on in high resolution in Mumbai, but for me Anil was the spectroscopist. I knew his papers of course, with Richard Ernst, and we had a scientific overlap. They looked at double quantum effects as we do. I was very impressed, but I was not aware of the starting point of the development. When I really got exposed to the NMR community in India, it was from Madhu, when he joined as a postdoc, after that I don't know how many times I have visited India. I guess, in the order of 10!

Anusheela: After his Ph.D., Madhu started his career in your lab. Your association with him has been especially long, and now when somebody talks about NMR research in India, Madhu's name stands out. How does that make you feel?

Shimon: I feel lucky. I didn't create his mind, he came to us. He has these general ideas, even before he knows how to do it. And at very important times, he guided us with his ideas. He also did work, not saying he only had ideas but he had this vision that was important. He has this capability which not many people have, that is that if he answers something, he tries in his mind to make everything better. Take a starting point and make it better. For example, he is the leader of this FAM (fast amplitude modulation) business, but then later he suggested a change in the pulse sequence to get it better, and that is Madhu. He was very much involved in PMLG (phase modulated Lee-Goldberg) development, with Elena and later with Michal. He tried to do the next step when we were doing the first step. I am sure you have the same experience with him. He has an enormous knowledge about what is going on, but he thinks about how to do it better. I don't know anything about his interests in going to applications, because I am not in that field, amyloids are outside my knowledge. However, you can see rCW (refocussed continuous wave). It is a very simple idea but (he) figures out how to do it and then he knows also to activate you, where he needs you. I don't want to use need, need in a positive way not a negative way. Even in rCW, he came to us and said, “Ask Michal, can you do the theory for that?” That is Madhu for me.

We had very good contact, personal contact, of course. Otherwise things don't work. And it just flows. We are in a group and I was lucky to have very good students; together or under his guidance. That contact stayed not so much in the sense that when he wanted us to do something, in that framework that we will do it together. An important person is not made by other persons. They are special in their own ways and when they get basis, they stand out. I don't believe I created scientists, I was lucky that they were good scientists and we did it together. It turned out

Prof. Shimon Vega, during his talk at the 'NMR Meets Biology, 2018' meeting that they did good jobs. I give credits only to others. That's how I look at it.

You know, the appreciation of what people contribute is important, especially, if you are in the period of your own development. Sometimes, we forget where ideas come from and what the dynamics to create these ideas was. I am not saying to overdo it. Perhaps they couldn't have done it without me, that I agree but the credit goes many times to their questions, their ideas and to their pushing in certain directions. That's how I look at science.

Anusheela: Coming back to science, if you think about a scientist's day to day life, you face failures quite regularly. It is not every day that you get positive results. It may take months to get something that is remotely pointing towards success. How do you deal with failure?

Shimon: I think many people have that in parallel; you work in your field in one or two directions. One may not be going the right way, but you make some progress in the other direction. Now in my case, because my group was always small, and that Madhu will also tell you, I had daily contact with everybody. It is because of the fact that theoretical part needs guidance; it is not that I invent it but it needs to be guided, and it needs this personal contact. And there the failure is different, the failure is not that you did an experiment and it didn't work out as predicted. It goes together; you create a theoretical framework, do experiments and try to fit the results. And then the question comes: which is correct? Experiment or theory? And there sometimes, it is more of a frustration than failure in my case.

I tried all kind of things that didn't work. But then you know you are stuck with some kind of concept. I always used to work out the theory, but I am not a theoretician. You have a mathematical model to explain something, and you believe in that so you say, "Okay this experiment should have given A." So, we need to modify that model or the experiment does not belong to that model. So, of course, there were failures, but I don't think my career was filled up with failures. Disappointments, yes. But it is not the same in my eyes. You hope something will go in a way, but then in the experiment you see it is totally different, you go back to your way of thinking and see 'Oh! There I made a mistake. I should have thought like this, or written it like this."

Anusheela: It is the learning curve!

Shimon: Yes, all the time. But then the price you pay is that you are busy 24 hours. That, for your family, is terrible. I realise it today. I do not have the patience to read a book. I am near the end of my career and I would like to finish few things, so when I go home and sit with my wife, I don't read a book, I sit with my laptop. She is used to that, but that is the price you pay.

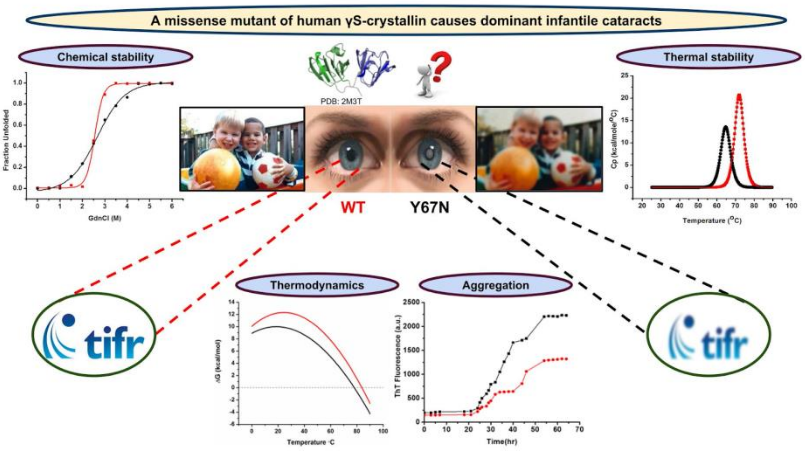
You think about your science. You try to solve it, and there is also something in science, you think that you are almost too late, because somebody else is going to do it.

(Prof. Shimon Vega was interviewed by Anusheela Chatterjee.)

1

Infantile cataracts are a root cause of blindness in children. When a cataract develops in the eye, the lens slowly becomes opaque. A mutant form of Gamma S-crystallin, a protein abundant in the eye lens cortex, is associated with this form of cataract. A study, led by Prof. K.V.R. Chary, tried to uncover whether this opacity was caused due to any structural and functional changes in the mutant form of Gamma S-crystallin. With the help of sophisticated spectroscopic experiments, it was found that the mutant protein was structurally unstable as compared to the healthy protein, and this structural weakness is caused by a change in the 67th amino acid of this protein.

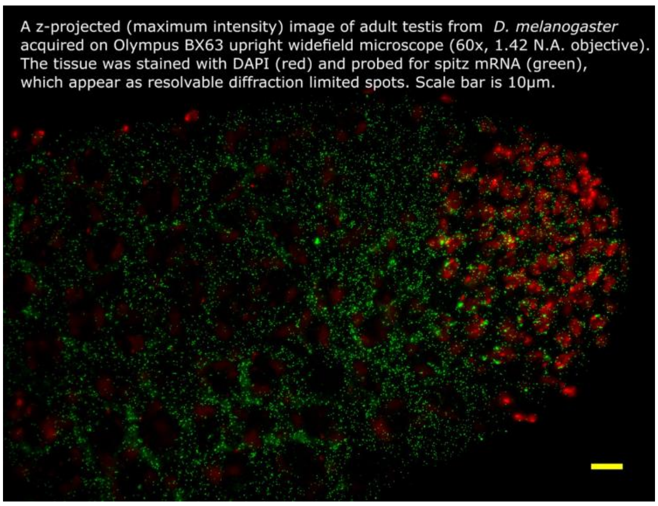
Jishan Bari
PI: K.V.R chary



2

Cells communicate using convoluted chemical signals. Given the limited number of proteins, how does a cell assess the input message and act accordingly? One plausible approach could be by applying different strengths of the same input. Using Drosophila melanogaster, the fruit-fly, as a model system, a method was adapted and modified: single-molecule mRNA fluorescence in-situ hybridization (smFISH) for whole-mount tissues. smFISH quantitatively gauged transcription of the target genes, and was used as a proxy to determine the input signal strength. In the lab, smFISH is being applied to understand how different signal strengths can bring about differences during the development of the fly.

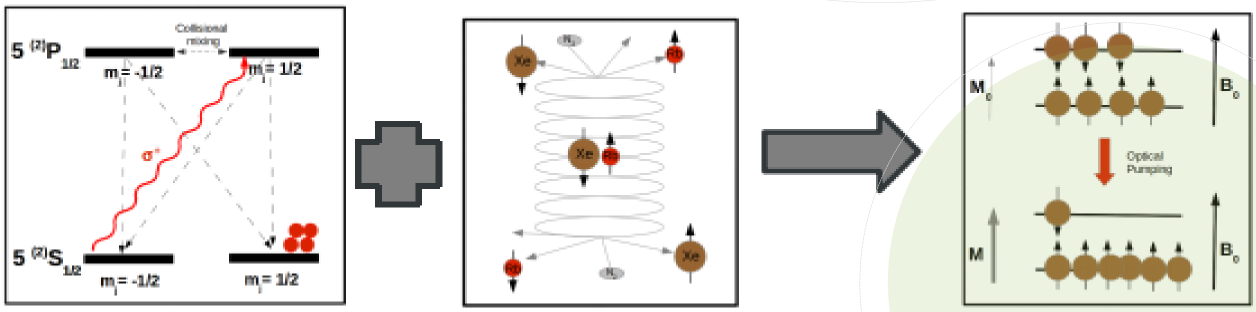
Nikhita Pasnuri
PI: Aprotim Mazumder


A z-projected (maximum intensity) image of adult testis from *D. melanogaster* acquired on Olympus BX63 upright widefield microscope (60x, 1.42 N.A. objective). The tissue was stained with DAPI (red) and probed for spitz mRNA (green), which appear as resolvable diffraction limited spots. Scale bar is 10µm.

3

NMR signals detect the effective spin polarisation of the sample in the direction of the applied magnetic field. The polarisation of the sample depends on the difference in the number of nuclear spins that are aligned along and opposite to the fields. Even at the largest magnetic fields used for NMR experiments, this difference in population is pretty small, making the NMR detector look for a small needle in a haystack of ambient noise. The spin polarisation of the sample can be enhanced for certain noble gases like Xenon using laser light. Alkali atoms like Rubidium, are polarised by absorbing laser light and when Xe interacts with polarised Rb atoms, the polarisation is transferred to the Xe molecules.

Dr. G. Rajalakshmi

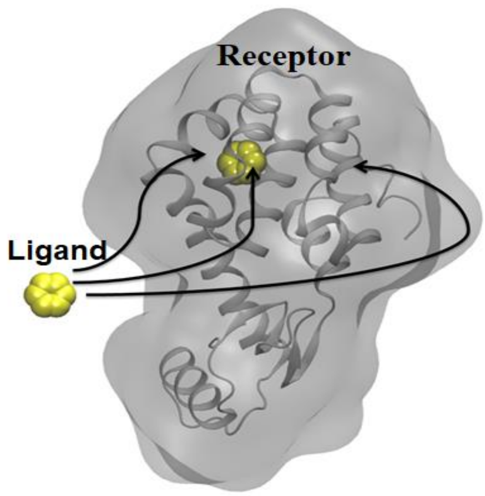


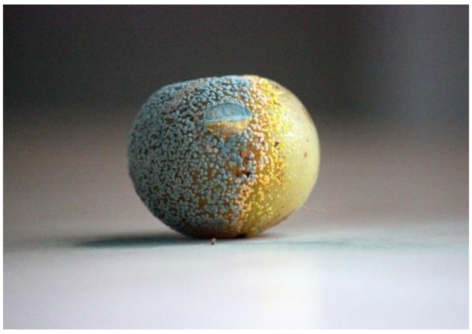
Rb optical pumping   Rb-Xe spin exchange   Xe Hyperpolarisation

4

The process of Ligand-binding to solvent inaccessible cavities in receptor proteins has been rather elusive. A study, led by Dr. Jagannath Mondal and Dr. Pramodh Vallurupalli, tried to gain mechanistic insight into the different pathways by which benzene, a ligand, can find its way into a deep-seated cavity in the mutant form of the T4 Lysozyme, a protein receptor, at an atomistic level.

Navjeet Ahalawat
PI: Jagannath Mondal and Pramodh Vallurupalli





Ode to a busybody

Once in a while, or maybe more often,
You feel the urge to simply stop the reaction.
Just go out, watch a movie or a play,
As inside the Institute, it feels unbearable to stay.
Go around ask a friend, as their code finishes compiling,
Another compatriot in the left wing, who flies be defiling.
"Hey busybody, would you like to go?", as four fills the cab,
"I'd love to, but there's something-something to do in the lab."
"It's only two hours, and your time management fares poorly."
"I've done nothing for three days, now's not the time surely."
"Fine, do as you wish, any end to your work spree?"
"On the third Saturday of next month, I should be free."

Sumit Bawari
Graduate student, TIFR Hyderabad

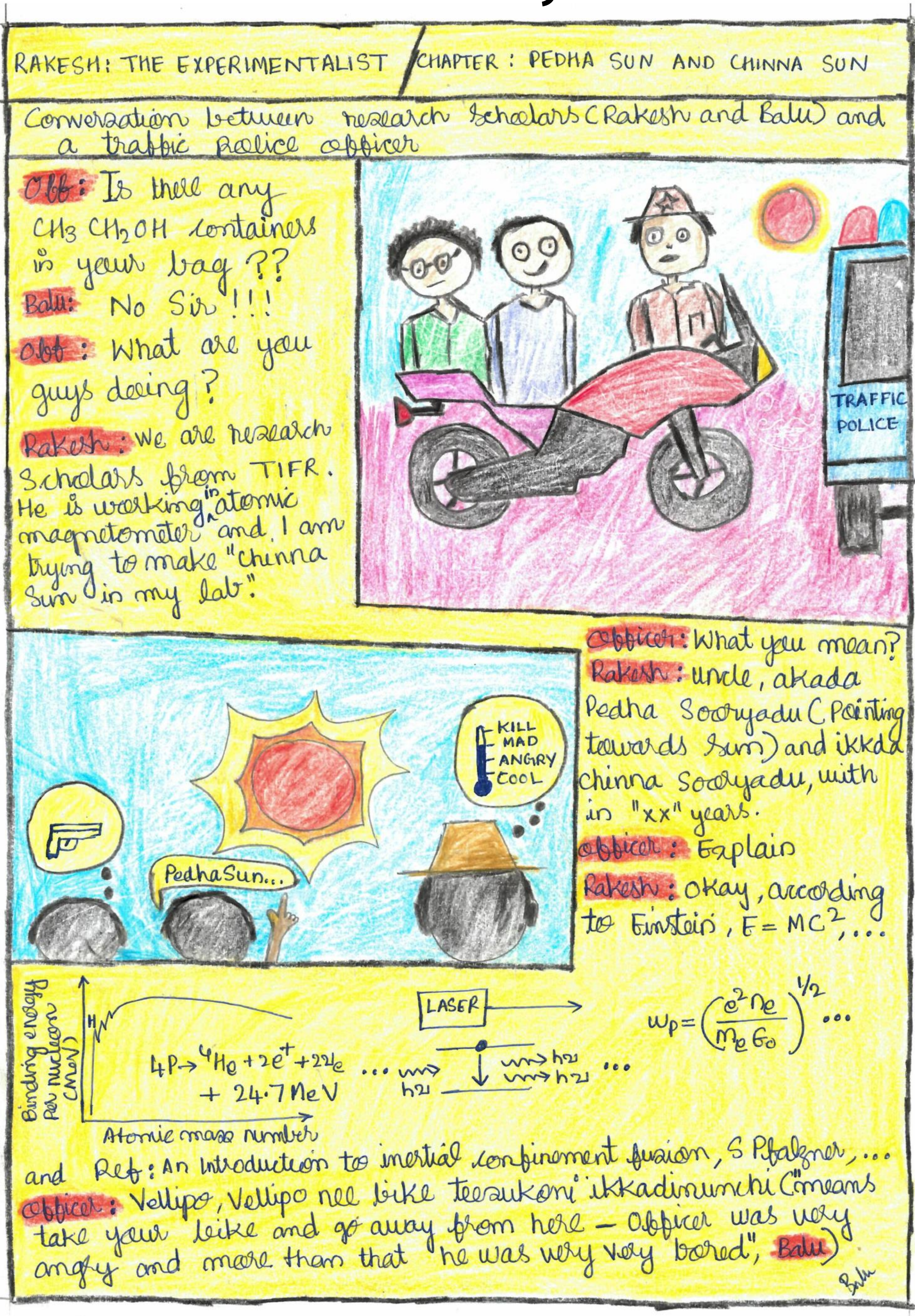
Photographs (top to bottom):

1. Bird's nest from plot - B, TIFR-Hyderabad.
   Captured by P.S. Kesavan (Graduate student, TIFR Hyderabad)

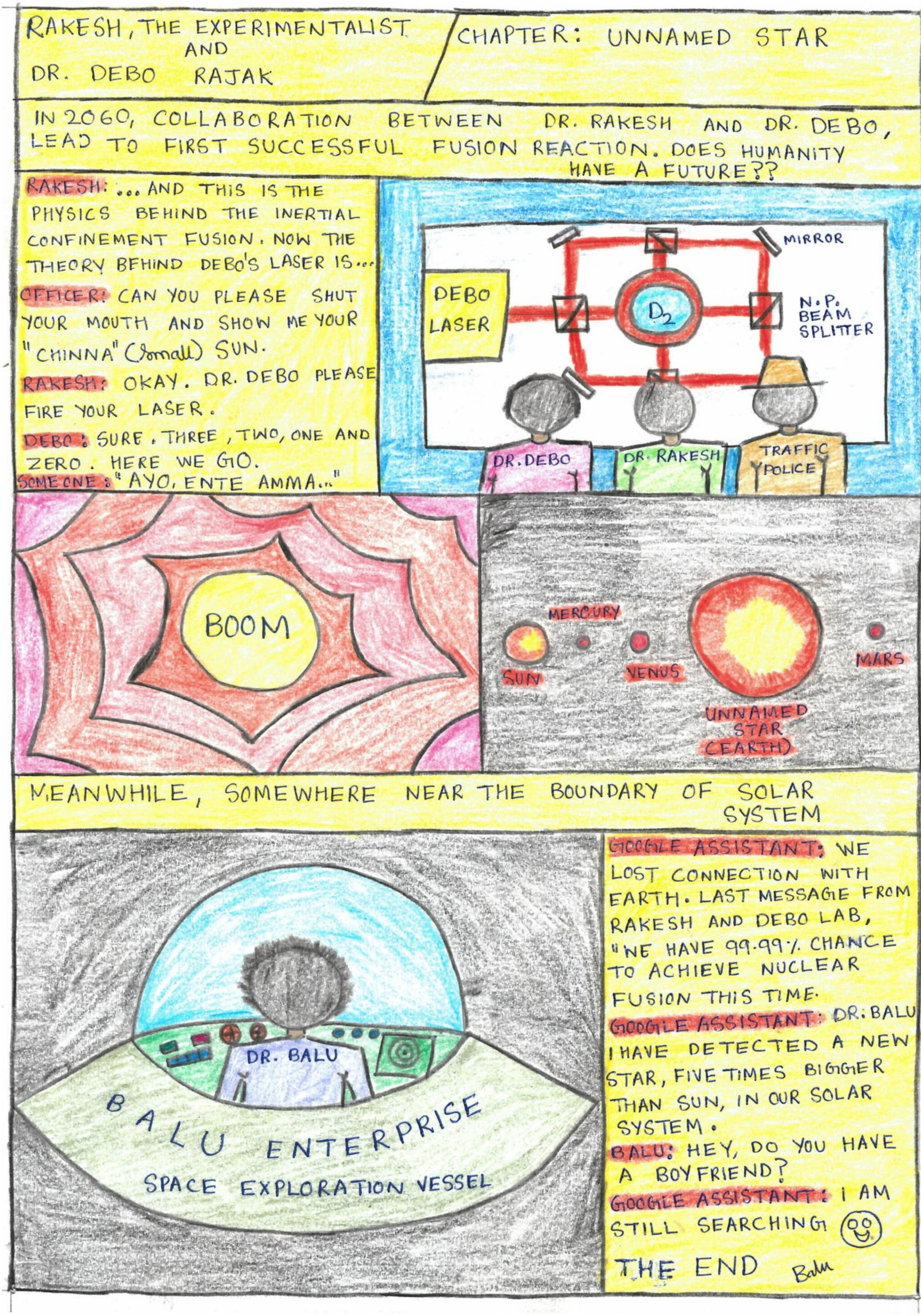
2. Green bee-eater, in flight, outside the TCIS canteen.
   Captured by P.S. Kesavan (Graduate student, TIFR Hyderabad

3. Rotten Indian gooseberry.
   Captured by P.S. Kesavan (Graduate student, TIFR Hyderabad

4. Dragonfly.
   Captured by Vineeth Francis T.J. (Senior Research Fellow, TIFR Hyderabad)



Cartoons by Vineeth Francis T.J. (Senior Research Fellow, TIFR Hyderabad)



Cartoons by Vineeth Francis T.J. (Senior Research Fellow, TIFR Hyderabad)