Curiosity never sleeps.
That's why we'll be back, with more questions, more stories, and more science.

HELICASE | Fall Edition 2025
A Science Magazine by The Science Club, IISER Pune
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Rooted Anew

De Novo Root Regeneration in *Arabidopsis thaliana*

2025

HELICASE

Fall Edition

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HELICASE

2025

Fall Edition

The Science Club

Indian Institute of Science Education and Research

Pune-411008

HELICASE *Fall Edition, 2025*

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Front Cover Image: De Novo Root Regeneration in Arabidopsis thaliana
The cover showcases a rare yet remarkable phenomenon in plant survival strategy: de novo root regeneration. Captured here is a leaf of Arabidopsis thaliana giving rise to new roots—an adaptive process where mature leaf cells undergo dedifferentiation and reprogramming to assume a new fate.

Originally photosynthetic, these leaf cells have transdifferentiated into root-forming cells, enabling the plant to recover and restore function under stress. This elegant reallocation of cellular identity reflects the inherent plasticity and intelligence of living systems—constructing anew, from scratch.

Image Credit:
Amish Butle, BSMS'24 student, IISER Pune

FROM THE COORDINATORS' DESK

~ Now with 47% more helicity ~

Dear readers, mutants, and time-traveling versions of ourselves,

It is with quantum levels of excitement that we unzip this year's Fall Edition of Helicase, back from its cryogenic slumber, fully recharged and positively exothermic in enthusiasm. Like a well-behaved protein, we've refolded the magazine with extra domains, better structure, and fewer beta-sheet breakdowns. Yes, we've checked for prions.

This edition spirals into the heart of IISER Pune's vibrant scientific culture, covering everything from **Nobel Evenings** to new faculty features, from cutting-edge research highlights to **MS Thesis Shenanigans**. We even let physicists write stuff. Risky, we know.

You'll find **Curriculum Unplugged**, your syllabus never told you they were this cool. You'll meet researchers with origin stories worthy of superhero comics. A special shout-out to the professors who took time away from battling stubborn fungi and decoding complex genomes to speak with our team. And to the daring souls who answered "Can I write something fun?", spinning tales of resurrected direwolves and time crystals.

The interviews go deeper than a black hole's event horizon, the photography captures more beauty than a double rainbow in a Petri dish, and the reflections hit harder than Newton's third law on a trampoline. Our extended features include thought pieces, model-making adventures, and first-hand accounts of workshops and talks, with contributions from across disciplines. We're also particularly proud to showcase a dedicated **Women in Science** segment, because equity in STEM shouldn't be a Heisenberg uncertainty but a constant, like Planck's, only less tiny and more inclusive.

You'll also find an **Internship & Scholarship Hub**, reflections from students who won **Best MS/PhD Theses**, and deep dives into talks ranging from the Higgs-Boson to Han Kang. Some pieces are heartfelt, others delightfully chaotic. From the stalls we ran on **National Science Day** that pulled in curious wanderers, to the **Pi Week** booths where π(e) met pastry and probability, to the interactive exhibits at **SciCon** where science got the spotlight it deserves. We've tried to capture the curiosity and character of it all.

After that turn the page and you'll find a **Fun and Games** section with chess puzzles, science-themed crosswords, and maybe, just maybe, a subtle nod to that coffee-fueled meeting with Dr. Pawfessor, who stared judgmentally from the windowsill the entire time, tail flicking with editorial intensity. We almost named the issue HeliChai, but he blinked twice and that was the end of that.

We can't promise this magazine will solve your assignment woes or fix your failed gel electrophoresis. But we can promise a good read, a few laughs, and perhaps that warm fuzzy aha moment when science just clicks.

Thank you to everyone who poured their ATP into this issue. From article writers to layout tinkerers, from those who answered emails at 2 AM to those who silently added Oxford commas where needed, Helicase wouldn't spin without you.

Now go forth and unwind, because the Fall 2025 edition is finally here.

With helicity and hype,
The **HELICASE** and **Science Club Coordinators**
The Science Club, IISER Pune





From the FACULTY COORDINATOR

“Does a science institute like ours need a Science Club?” was the question that came to mind when I was approached to be the Science Club faculty coordinator in 2021. A doubt I had was - would the activities they organize be redundant to the talks, seminars, and conferences that are inherent to a campus like ours? A few years later, I have changed my mind.

First of all, the Science Club is a fully student-driven initiative. All ideas come from the students, and are planned and executed by them. Hence, the nature of activities conducted by the science club such as talks and seminars are complementary to the faculty-led ones.

Secondly, the Science club is a way for our students to showcase science as they see it. What students perceive as interesting, important, indulgent, and intriguing is often complementary to my view, and I have learned immensely from my interactions with the Science club coordinators and volunteers over the years.

Finally, the diverse, fun, and colorful array of events, discussions, talks, and contests that the Science Club has put forth is enriching to the campus community. I will highlight three of my favorite ones from the past year – first, the Nobel Evening series that happens annually after the Nobel Prizes are declared. A faculty member from campus who is familiar with the field which was awarded the prize is invited to share their knowledge and view on the area. Second, the KYC (Know your Courses) series conducted for the incoming batch of students and the fourth semester students, who are at the juncture of specializing in a field of science. This series allows the collective wisdom of students to pass on from one batch to another with regard to the coursework at IISER Pune. This also provides a forum for students to get a sense of what to expect in courses beyond what is written in the syllabus. Third, I especially enjoy the games and events that the Science Club runs the year round – “Tangled Tuesdays” crossword series, the “Science in your backyard” photography competition, and the showcases at the National Science Day and Mimamsa Science Convention are some that I have personally enjoyed.

I hope you too realize the vital role of a student-led Science Club on a student-centric campus like ours, and join us on the journey that we take this year! For now, please enjoy reading this Fall 2025 edition of Helicase, and celebrate the spirit of science at IISER Pune put forth from the student’s perspective!

Regards,
Amrita Hazra, Associate Professor
Departments of Chemistry, Biology
Faculty coordinator, Science Club 2021-2025

SCIENCE CLUB
IISER PUNE

A NEW LOOK FOR A CURIOUS SPIRIT

In 2025, The Science Club unveiled its new official logo, marking a bold visual evolution in the club’s identity. This updated emblem is more than just a design. It represents a renewed spirit of inquiry, creativity, and student-driven science.

Crafted by ***Rudra Sahu***, a second-year BS-MS student and current Helicase coordinator, the logo is a convergence of symbolism and simplicity. At its core, the design embodies the flame of curiosity: dynamic, layered, and constantly in motion. The vibrant yellow arcs evoke the fluidity and growth of scientific thought, while the purple core represents the richness and depth of inquiry, experimentation, and collaboration.

The logo is both forward-looking and rooted in the club’s ethos. Its soft gradients and curvilinear forms hint at the blending of disciplines, where no boundary is too rigid, and no question too narrow. The design is meant to feel alive, mirroring the evolving nature of science itself.

This transformation comes at a time when The Science Club is expanding its presence and initiatives, from public science events and competitions to discussions, workshops, and this very publication, Helicase. The new visual identity stands as a reminder that science is not static. It is always unfolding, always spiraling upward.

We’re proud to carry this logo forward as the face of our collective curiosity.

EDITORIAL



SUHANI BHATTACHARYYA
Head Content Editor

"80% caffeine and 20% 'Do-you-want-to-see-pictures-of-my-dogs'? "



RUDRA SAHU
Design Editor

"Plays Kho-Kho but still can't outrun responsibilities"

HELICASE COORDINATORS



SOUMYOJYOTI PAL

"Spends more time with Chlamydomonas than actual humans!"



SIRI M. BHAT

"Hey Siri! Come up with a cool one liner for me please!"



SUSHANT ANAND

"Learning the science to eat fast!"

GENERAL COORDINATORS



RUPSA CHATTERJEE

"She's runway-level chaos with an infinite to-do list, oddly specific opinions, and the audacity to call it a lifestyle."



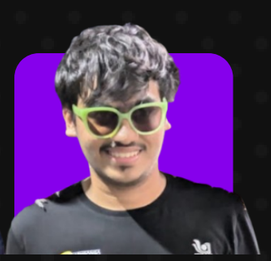
SARANYA RAY

"Proof that too much caffeine and too little sleep can be an aesthetic."



ANANDITA CHANDRAN

"Dual major in girl math and doing things for the plot"



PARTH SARDA

"..."

FORMER COORDINATORS



Angad Singh



Soumya Ranjan Nayak



Dhruv Jajodia



Jagadish P.



Pranidhi Deshmukh



Raafia Shaikh



Riddhiman Biswas



Anhad Jha



Neelanshi Jain



Smera Thejasri M T



Sojwal Rajmane



Ieshaan Saha



S V Ananthakrishna



Anargha Mondal



Anagha Mohan



Aaditi Mante



Harshal Pandit



Neha Nair



Yashvita Subramanian



Srishti Kar



Pranshu Nemani



Vakula Surendar



Gurjot Singh Sawhney



Nidhi Bhagwat



Raj Bagwe



Saloni Kumari



Sritama Senapati



Paw-fessor

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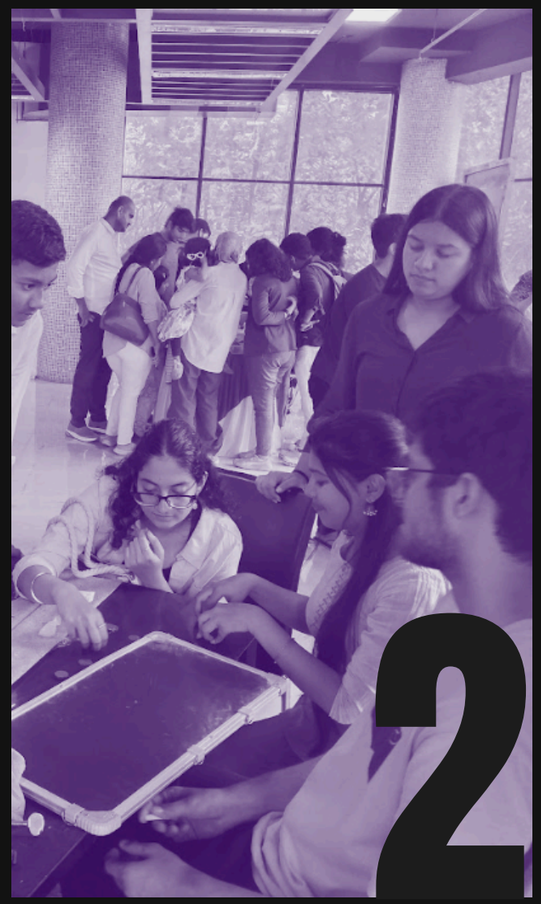

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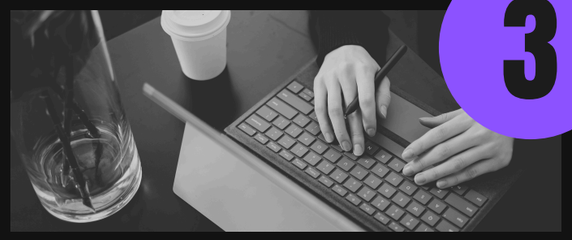

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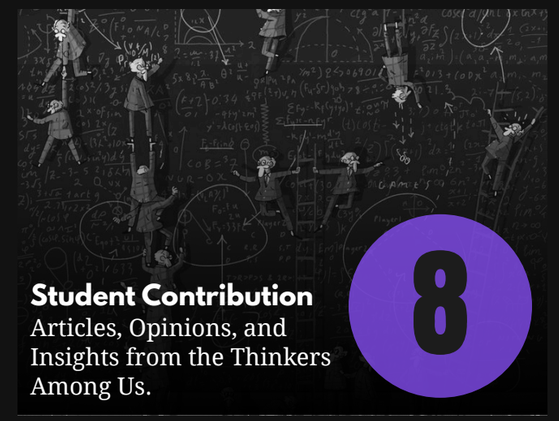

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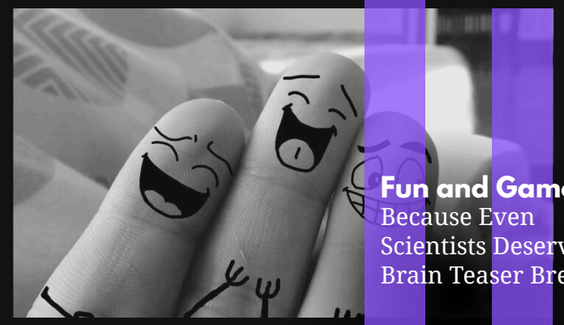

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HELICASE *Fall Edition, 2025*



SCIENCE CLUB
IISER PUNE

presents

NOBEL EVENINGS

"... to those who, during the preceding year, shall have conferred the greatest benefit to humankind ..."

Alfred Nobel (1833–1896)

PHYSICS

'Oh, well, if you prefer, I can recognize handwriting,' said the imp proudly. 'I'm quite advanced.'
Vimes pulled out his notebook and held it up. 'Like this?' he said.
The imp squinted for a moment. 'Yep,' it said. 'That's handwriting, sure enough. Curly bits, spiky bits, all joined together. Yep. Handwriting. I'd recognize it anywhere.'

- Terry Pratchett (Feet of Clay)

Soumya Ranjan Nayak ...

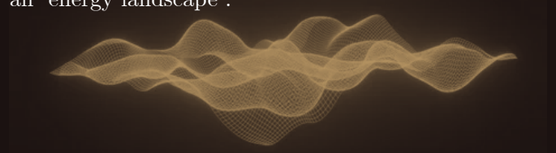
The Science Club had organised a talk on the NOBEL PRIZE IN PHYSICS 2024, by Dr. Bedartha Goswami on 16th November, 2024. Below is a summary of the Nobel Prize winning work.

The Nobel Prize in Physics 2024 was awarded jointly to John J. Hopfield and Geoffrey Hinton "for foundational discoveries and inventions that enable machine learning with artificial neural networks".

Try to recall the last time you heard a small snippet of a song you really like. Most likely, it took you seemingly no time to remember the song, its lyrics, the artists, and the good times that came with it. How does this "re-cognition" happen? Does the brain have a list of all song-lyric pairs that it searches through very quickly? If so, this database must contain a LOT of music indexing, stretching back to our childhoods. The seemingly normal task of remembering has suddenly become staggeringly computationally intensive.

This motif of navigating toward a specific outcome in very short times is a problem we see in other fields as well (notably, the protein folding problem/Levinthal's paradox). How does nature resolve this hitch? And, how do we model memory?

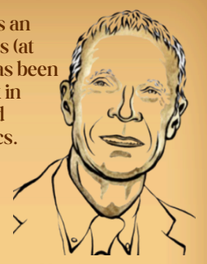
Memory can be thought of as retrieving the state of a system, say, when we have some faulty recollection of it. For each state, one associates a real number called energy. This energy is determined by the interactions among different components of the system. The space of all states (generally) has a very high dimension; the energy defined for all states in this space creates an "energy landscape".



Forces drive the state of the system so that it resides in one of the local minima (troughs) in this landscape. This way a lot of states around an equilibrium state eventually evolve and converge to one of a handful states. Congratulations! We can now remember things, given some initial ideas.

We can use this to demonstrate memory encod-ed in a system of a n by n grid of squares (think pixels), which can recognise a pattern drawn into it. If a square is drawn into, it is a +1, otherwise it is a -1.

John Hopfield



Born in 1933, the 91 year old is an emeritus professor of physics (at Princeton university) who has been highly regarded for his work in statistical physics, condensed matter physics and biophysics. In 1974, he introduced a mechanism for error correction in biochemical reactions known as "kinetic proofreading" to explain t he accuracy of DNA replication. He also coined the term "polariton" used in condensed matter physics. For his work in statistical mechanics, he was awarded the Boltzmann Medal in 2022, along with IISER Pune's own Deepak Dhar.

Before his work on Hopfield Networks, the field of AI research was said to be in a decay period, widely known as "AI winter".

In March 2023, Hopfield signed an open letter titled "Pause Giant AI Experiments", calling for a pause on the training of AI systems more powerful than GPT-4.

A weighted graph corresponding to this system is what is called a Hopfield Network. Squares are nodes that can take values 1 or -1, and each node is connected to every other, with the edges having connection weights. These are some positive or negative real numbers.



Geoffrey Hinton



Born in 1947, he is a University Professor Emeritus at University of Toronto, widely known as "The Godfather of AI".

With David Rumelhart and Ronald J. Williams, Hinton was co-author of a highly cited paper published in 1986 that popularised the backpropagation algorithm for training multi-layer neural networks.

Hinton received the 2018 Turing Award, often referred to as the "Nobel Prize of Computing", together with Yoshua Bengio and Yann LeCun for their work on deep learning.

In May 2023, Hinton publicly announced his resignation from Google. He explained his decision by saying that he wanted to "freely speak out about the risks of A.I." and added that a part of him now regrets his life's work.

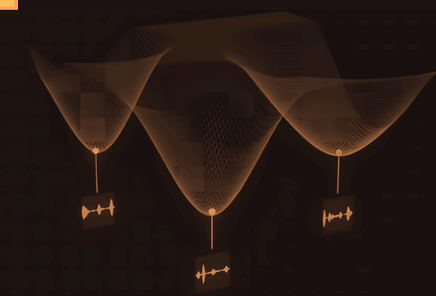
If the weights are fixed, there are 2^n configurations allowed in this network. The energy of a configuration is given as:

$$E = -\sum_{i,j}^{edges} w_{ij} x_i \cdot x_j$$

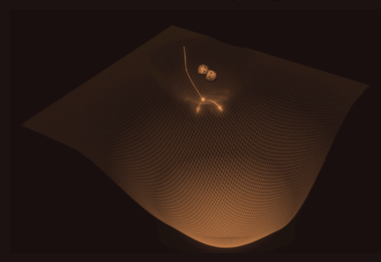
w is the connection weight
x represents the value of the node

To store a pattern in this network (say a smiley face drawn on the grid), all we need to do is make sure that specific pattern corresponds to an energy minimum. This is done by fixing the x's and then adjusting the weights - this is the "learning" process.

Once an energy landscape is thus created, one starts with any initial state in the landscape and tweaks the x values to lower the energy of the state. This changes the state of the system to one with lower energy, and the path that the system travels is the one of steepest descent. This is continued till any tweak increases the energy, and one ends up in a memorised lowest energy state. This is the "recall" process.



This has quite a few limitations: mainly one can store a maximum of only 14 patterns in a grid of 100 squares. Sometimes the valleys created by two correlated patterns are closely spaced and they interfere with each other, causing bogus states to be recalled. (see the first illustration of the energy landscape)



This Hopfield Network is good at recognizing patterns. What about creating new patterns from the ones it has already learnt?

Geoferrey Hinton (along with others) made one small modification - instead of deterministically descending down the gradient, the direction of travel is randomly determined according to the boltzmann probability distribution. This allows the state to climb out of a well and explore the energy landscape, an analogue for varied/creative thinking! Say hello to the Boltzmann Machine. It not only memorises, but "understands" the nature of patterns it learns.

There are corresponding modifications in the learning process (creating peaks for the useless areas in the space: "contrastive learning"), and many complications and modifications one can make to this (e.g. adding "hidden layers" - a sort of internal storage that speeds up the recall process)

The Hopfield Network and the Boltzmann machines serve as tractable, but very illuminating starting points that led to a chain of developments contributing to the rise of AI's prominence in recent years.

A Brain-Inspired Algorithm For Memory

At the time of announcements of these prices, there was widespread debate about the prizes not being about "physics". While it is true that these developments led to revolutions in computer science and other disciplines, and the recent attention garnered is due to AI's infiltration in everyday life, the roots lie in statistical mechanics. Aside from the obvious Boltzmann related things, the astute reader would notice the energy function being identical to the Ising-Model hamiltonian. The different interaction terms for every pair would make this a "spin glass" system. Problems like the number of patterns stored in some size of the grid were especially the areas of interest of Giorgio Parisi, the 2021 Physics Nobel Laureate, amongst other statistical physicists.

Generative Model That Won 2024 Nobel Prize

CHEMISTRY

Riddhiman Biswas ...

The Science Club organised a talk on the NOBEL PRIZE IN CHEMISTRY 2024, by Dr. M. S. Madhusudhan on 11th November, 2024. Below is a brief summary of the Nobel Prize winning work.

The Nobel Prize in Chemistry 2024 was divided, one half awarded to David Baker "for computational protein design", and the other half jointly to Demis Hassabis and John Jumper "for protein structure prediction".

Sunsets with their dark red hue aren't just beautiful - it's biochemical. You effortlessly read this line, while noticing the colour at the same time. This process, called visual phototransduction, is made possible by several tiny molecules - the most prevalent being proteins, like rhodopsin. They convert the electromagnetic wave into electrical signals for your brain, which you then interpret as beautiful; or maybe not?

Proteins have a ubiquitous presence in our body, dealing with several different functions like signal transduction, DNA replication and repair, transportation - literally almost any process you could name. Crucial for the normal functioning of the protein is its 3D structure (a crucial example being sickle-cell anaemia). Yet, for much of the last century, the process of how a protein finds its shape (and if we could predict the pathways) remained a mystery.

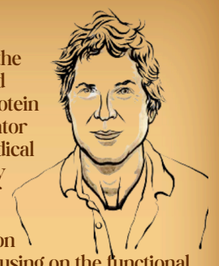
By the 1990s, many groups were experimenting with various force fields and homology modeling[*Background from ref*]. However, *de novo* structure prediction or predicting the protein structure solely from the sequence became highly successful after Baker lab introduced the Rosetta algorithm. While it used the known structure database for understanding the structural patterns, Rosetta did not rely on direct similarity to any specific sequence or template, making it a true *ab initio* approach.

Rosetta tries to predict how a protein folds by building it piece by piece. Short stretches of amino acid sequences tend to form specific local structures - however, these local structures can exist in various conformations for different proteins. These local structures then interact nonlocally to form the final conformation. Rosetta forms a fragment library of structures from the protein structure database that these short sequences are known to form [*Rosetta from ref*].

Rosetta emerged as the leading *de novo* method, with foundations being laid for many extensions like loop modeling, protein-protein docking, and ultimately *de novo* protein design. And that's exactly what Baker did next.

In 2003, Baker's group designed a brand-new protein for the first time - one that never existed in nature, and yet folded reliably in the lab - using similar approaches to Rosetta. The result was Top7, a 93-residue α/β protein with a novel topology and an experimental structure that deviated by just 1.2 Å RMSD from the computational model.

David Baker



Born in 1962, David Baker is a professor of biochemistry at the University of Washington and director of the Institute for Protein Design. He is also an investigator with the Howard Hughes Medical Institute (HHMI). He primarily works on the development of new computational methods for protein structure prediction and even designing them, focusing on the functional aspects. He also has an experimental biochemistry lab and has authored several highly cited papers.

Primarily known for developing the Rosetta algorithm for ab initio protein structure prediction, his lab has also developed a computing project Rosetta@home, the computer game Foldit and RosettaFold. His lab was the first to design an artificial protein with a novel fold, Top7. He has been awarded numerous prizes including Breakthrough Prize (2021), Feynman Prize in Nanotechnology (2004), and Newcomb Cleveland Prize (2004).

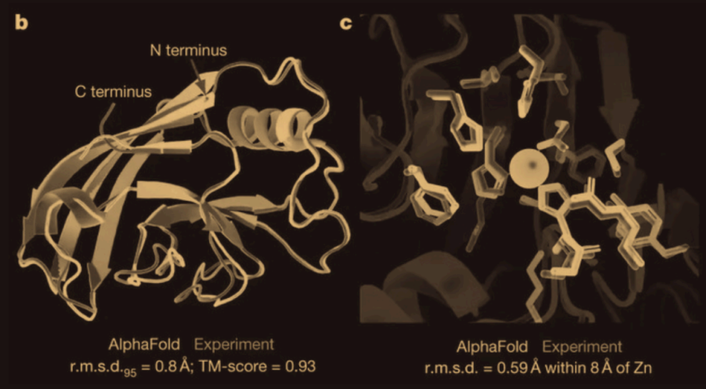
Baker launched Rosetta@home, a distributed computing project that lets volunteers donate spare computing power from their devices to run protein folding simulations. In 2004, Baker's team launched Robetta, an online server that automated the process of structure prediction based on Rosetta. He also launched Foldit in 2008 - a multiplayer online game where non-experts fold proteins via an interactive interface. Players discovered novel folding strategies that sometimes outperformed the algorithm itself. They argued that human reasoning could help identify strategies to pursue suboptimal conformations instead of using stochastic (or random) search.

Demis Hassabis



Born in 1976, Demis Hassabis is an AI researcher, and entrepreneur, currently serving as CEO and co-founder of DeepMind, an AI company acquired by Google in 2015. He is also the founder of Isomorphic Labs under Alphabet Inc. (parent company of Google) and is a UK government AI advisor.

Hassabis led the development of AlphaGo, the first AI to defeat a human Go champion, and later AlphaFold, which made significant progress in the field of protein folding. For his contributions, he has been elected as a fellow to the Royal Society and won many prestigious awards including the Breakthrough Prize (2023), and the Lasker Award among others. In 2024, he was knighted and has been on the Time 100 list twice (2017,2025) featuring on the cover in 2025 as well.



DeepMind was founded by Demis Hassabis, Shane Legg, and Mustafa Suleyman in 2010, using deep learning to initially teach artificial intelligence how to play old games from the seventies and eighties. In 2016, AlphaGo (an artificial neural network from DeepMind) beat Lee Sedol in a game of Go, becoming the first computer Go program to have beaten a 9-dan professional without a handicap. After this, DeepMind turned its resources to the problem of protein folding.

CASP (Critical Assessment of Techniques for Protein Structure Prediction) is a biennial, communitywide blind test to predict the unknown structures of protein. This is important to objectively assess the quality of predictions made by various computational approaches.

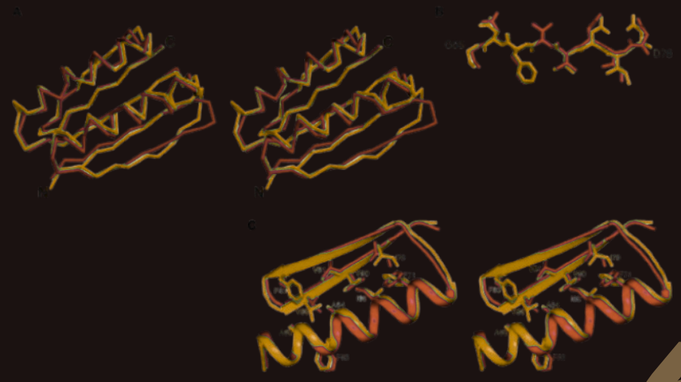
In CASP XIII (2018), DeepMind submitted results from AlphaFold - a deep learning neural network. It was able to score much higher than competing methods, but could not outperform template-based modelling (or one that used homology primarily), where Baker's RosettaCM still held quite strong. However, CASP XIII reported general use of deep learning techniques which had significantly improved the residue contact prediction between pairs of residues, improving almost every structure prediction.

John Jumper



Born in 1985, John Jumper is a computer scientist and computational chemist. He currently works at Google DeepMind as their director. He has a PhD in theoretical chemistry from the University of Chicago in 2017 with a thesis being 'New methods using rigorous machine learning for coarse-grained protein folding and dynamics'.

He made important contributions to the development of AlphaFold and AlphaFold2. In 2021, he was included in the Nature's 10 list. For his contributions, he was jointly awarded the Breakthrough Prize (2023), and the Lasker Award, along with Demis Hassabis, among others awards.



In CASP XIV (2020), DeepMind competed with a newer version, AlphaFold2, outperforming almost every other method by a huge margin. Directly quoting the CASP report - "...the results represent a solution to the classical protein-folding problem, at least for single proteins". However, it's important to realize that many groups had already reached the level of AlphaFold1 by then, even developing web servers and extending to a wider range of tasks like docking.

Before proceeding deeper into the network architecture of AlphaFold2, as the authors of CASP XIV have also mentioned, AlphaFold2 doesn't completely solve the classical problem of protein folding. Essentially, the prediction should be possible without any evolutionary information fed. There is also an uncomfortable point - we don't really know the physics of the process since we don't really know what the machine is doing.

Architecture of AlphaFold2

AlphaFold2 is trained on a hybrid dataset - 25% from the already existing structures in PDB and the rest (75%, yeah easy to calculate) from self-distilled data [*Self Distillation from ref*].

This hybrid data set is looped over while applying certain operations every time to promote diversity. The operations include quality filtering, MSA (Multiple Sequence Alignment) block deletion, MSA clustering, and residual cropping [*0 from ref*].

Then, we come to the next part of the architecture - input embeddings. Raw input data is now converted into numerical representations which contain information about the amino acid sequence, MSA features, and the extra MSA features as well. This is taken in to output MSA representation and pair representation of residues (size N_residue X N_residue)][*1 from ref*].

Next, we come to the important parts of the architecture - the Evoformer (the Transformer part) and the Structure Module.

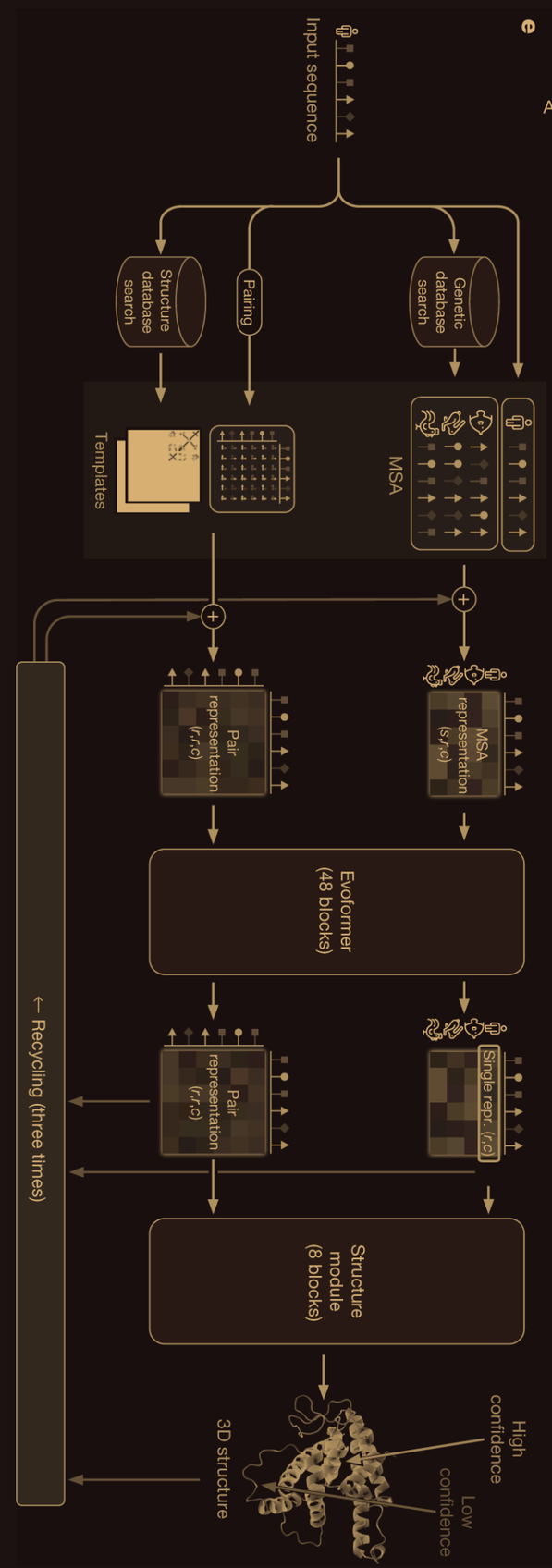
1. The Evoformer is the core neural networkInfo in ref. part. It takes in both the MSA and pair representations and iteratively updates both of them through the 48 blocks or layers. Each block takes the MSA and pair representations as input and outputs updated versions, which serve as input for the next layers via the residual connections we spoke about before [*2 from ref*].
2. The Structure module then takes the learned MSA and pair representations and converts them into 3D atomic coordinates. The protein backbone is represented as a series of local coordinate frames, one for each residue. Here's an interesting part - all the frames start at the origin called the 'black hole initialization'. This means all residues overlap at the same point - a highly unphysical situation but this simplifies the learning process.
3. The Structure module has 8 layers [*3 from ref*]. After all 8 layers, the module outputs the final backbone frames for each residue, predicted torsion angles for side chains, and full atomic coordinates for all heavy atoms (everything other than H). It also predicts a confidence measure, the pLDDT score which estimates the local accuracy.
4. However, in spite of all these, there still are physical violations like steric clashes. Removing these energy minimizations is done using the AMBER99SB force field with restraints applied to heavy atoms to allow the structure to relax near the input structure. If the residues still have violations, restraints are removed and the entire procedure is repeated till there are no physical violations.

And voila! You have the structure ready!

<u>Future Directions:</u>

While clearly AlphaFold2 has achieved a historic feat in structural biology, a lot remains to be done.

In 2023, AlphaFold3 was introduced by DeepMind and Isomorphic Labs, expanding beyond just protein structures to predict the joint structure of complexes including proteins, nucleic acids, small molecules, ions, and modified residues... Unlike AlphaFold2, AlphaFold3 uses a diffusion-based generative model.
Meanwhile, RosettaFold, developed by the Baker Lab, takes a different route. Its newer versions like RosettaFoldNA and RFdiffusion explore multi-chain complexes, nucleic acid interactions, and even *de novo* protein design. This allows us not just to predict structures, but to come up with new ones that nature hasn't made yet.
These models however still face challenges - dynamics, post-translational modifications, membrane interactions, and the physics of folding remain imperfectly captured.



MEDICINE/PHYSIOLOGY

Aaditi Mante ...

The Science Club organised a talk on the NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE 2024, by Dr. Anjan K. Banerjee on 16th November, 2024. Below is a summary of the Nobel Prize winning work.

In the microworld of cells, the emergence of new definitions and traits is not unusual. With the advent of notable technologies and insights, some understood the importance of regulation of genes within a cell, while some others began using various model organisms to interpret the evolution of genes. No, this is not solely the picture involving the Nobel prize winners, but includes many of the researchers before some revolutionary discoveries about the way genes are regulated were unveiled.

In the decades-long expedition to understand the mechanisms behind transcription and translation, the roles of transcription factors and microRNAs have long been considered significant. It was when the complexity in cellular functions of multicellular organisms was studied, scientists found that the information for regulating genes in a specific cell type is encoded in its genetic material itself. This implies that the time when a gene is transcribed into RNA and translated into protein via efficiently mediated steps is crucially important.

Let us now look at the role of a model organism, in particular, *C. elegans*, whose traits, such as short generation time, etc., and smoother ways to alter its genes, led to parallel discoveries in the mechanism of its organ development. These discoveries by the Nobel Laureates (2002), namely, S. Brenner, J. Sulston, and R. Horvitz, laid the foundation for the studies undertaken on the mutant species of *C. elegans* later on. Among the many mutants discovered in the Brenner and Horvitz labs, respectively, were lin-4 and lin-14 that displayed temporal developmental defects in the worm.

At the time Victor Ambros joined the Horvitz lab as a postdoctoral fellow, he found strikingly opposite defects in the lin-4and lin-14 mutants. Soon after completing his PhD, Gary Ruvkun began his research (1982) on the questions revolving around worm genetics by working jointly with W. Gilbert's and R. Horvitz's labs. The idea of cloning and sequencing genes for study purposes had become a possibility by then. With years of research and experimentation, both Ambros and Ruvkun, having obtained new faculty positions in different institutes, started gaining insights into post-transcriptional gene regulation.

Victor Ambros



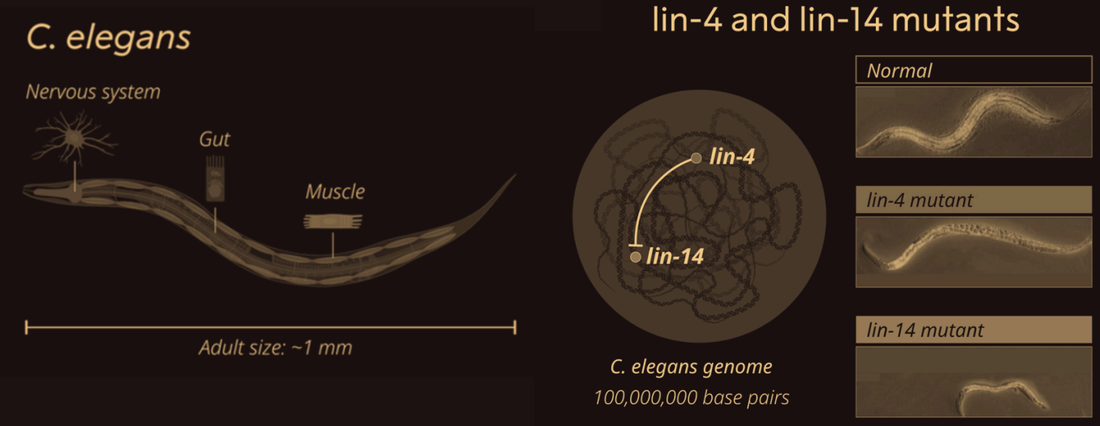
Victor Ambros is the Silverman Professor of Natural Sciences in the program in Molecular Medicine at the University of Massachusetts Medical School. He was a faculty member at Harvard, but was denied tenure, which resulted in Harvard losing out on a future Nobel Laureate as their faculty member. He has also won the Lasker Award 'for discoveries that revealed an unanticipated world of tiny RNAs that regulate gene function in plants and animals'.

On June 11, 1992, after obtaining sufficient data on lin-4 and lin-14 genes, Ambros and Ruvkun exchanged and compared it over a discussion where they found somewhat comple-mentary elements in their sequences. This led to further experimentation and a result which concluded that the lin-4 microRNA (discovered after multiple investiga-tions in the Ambros lab) regulates the lin-14 mRNA. These results were published in Cell in 1993 and were considered a major turning point in their joint research.

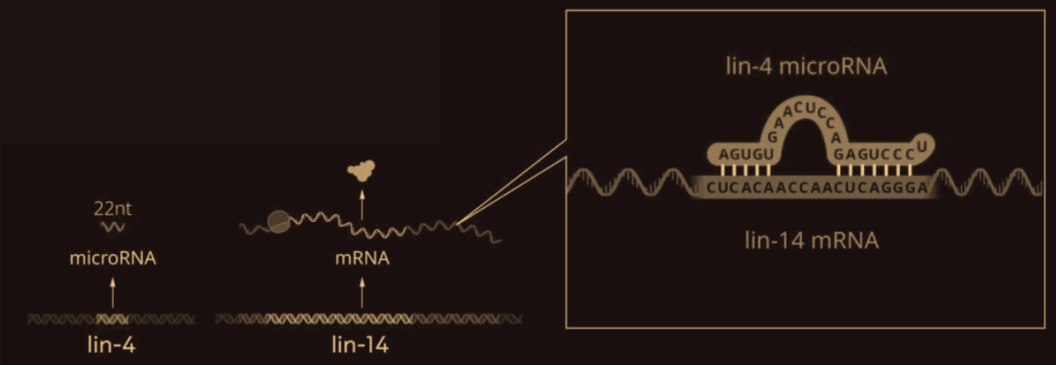
Gary Ruvkun



A professor of genetics at Harvard Medical School, Gary Ruvkun was a co-recipient of the Lasker award for 'for discoveries that revealed an unanticipated world of tiny RNAs that regulate gene function in plants and animals' with Victor Ambros. An interesting project of his is the SETG (Search for Extraterrestrial Genomes) project, one of the aims of which is to develop a small instrument that can identify and send DNA sequence files from other planetary bodies back to Earth.



After the discovery of the first microRNA in lin-4, a second microRNA named let-7 was found in Ruvkun's lab (2000), which deepened the perspective on the roles of microRNAs, with them being thought of as post-transcriptional regulators of gene expression. Surprisingly, Ambros was not involved in this discovery until much later. Another notable finding about let-7 was that it is conserved across a wider range of animals (including human tissues) as compared to lin-4, universalising the role of microRNAs. Since then, a large number of microRNAs have been discovered to understand how cells grow, develop, and even die. This strongly suggests a lasting influence of the groundbreaking work by Victor Ambros and Gary Ruvkun, who received the Nobel Prize in 2024.



ECONOMIC SCIENCES

Suhavi Bhattacharyya ...

The Science Club had organised a talk on the NOBEL PRIZE IN ECONOMIC SCIENCES 2024, by Dr. Bejoy K. Thomas on 2nd December, 2024. Below is a summary of the Nobel Prize winning work.

"14 October 2024

The Royal Swedish Academy of Sciences has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2024 to

> Daron Acemoglu, *Massachusetts Institute of Technology, Cambridge, USA*
>
> Simon Johnson, *Massachusetts Institute of Technology, Cambridge, USA*
>
> James A. Robinson, *University of Chicago, IL, USA*

"for studies of how institutions are formed and affect prosperity"

They have helped us understand differences in prosperity between nations"

The Nobel Prize in Economics 2024 was awarded to Daron Acemoglu, Simon Johnson & James Robinson. They demonstrated how institutions shape the prosperity of nations. The colonisation of many countries by European countries occurred during the 1600s-1900s. During this time, every country was not colonised for the same purpose. In turn, the societal institutions introduced during this time, a lot of which remain pervasive till now, have been shown by the three laureates to shape how the economy of the respective countries have prospered differentially.

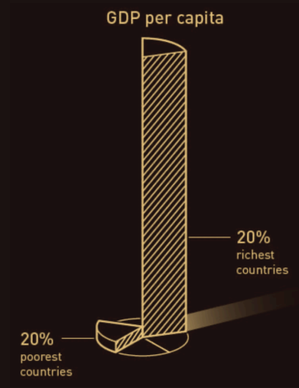
The question, "*So why don't poor countries simply copy what rich countries have done and catch up over time?*" is the vital question answered by the 2024 Laureates of Economics. They have shown how countries may get stuck in the vicious cycle of "extractive institutions" but they also say that it is possible to escape this trap and have a rule of democracy, which also leads to reduced poverty.

Colonisation by european countries can be roughly divided into two types, places where the indigenous population was denser and places where the indigenous population was sparse. In the densely populated places, the resistance from the indigenous population to colonisation would be more but upon colonisation, the cheap labour force positions would also be filled by that population. This made it undesirable for a larger coloniser population to settle in these areas. On the other hand, in sparsely populated areas, colonising "settlers" were more as it provided an opportunity for jobs and there was less resistance from the indigenous population. This resulted in places with denser indigenous populations having institutions which supported the "elite" colonisers over the general populace, while the sparsely populated regions, although they did not having a democracy, had laws and institutions that benefitted a larger population more.

Daron Acemoglu



The third ranker of the 2011 survey of Favorite Living Economists Under Age 60, Kamer Daron Acemoğlu is an Institute Professor at the **Massachusetts Institute of Technology**. He has been named most cited economist of the past 10 years per **Research Papers in Economics (RePEc)** data. He is Turkish-American of Armenian descent. Collaborating with James A.Robinson, Acemoglu has co-authored the book Why Nations Fail: The Origins of Power, Prosperity, and Poverty, which contains insights into a wide range of historical case studies supporting their Nobel Prize winning work.



Moreover, the mortality rate of colonisers in a country also affected the kind of institutions set up there as it affected the "settling" population of colonisers in the col-onised countries. In countries such as India and countries of Africa closer to the equator where the diseases were more likely to kill the colonisers as compared to diseases in places like New Zealand and Australia, the institutions set up were there to support and uplift the elite colonisers, rather than the general populace, since there were less settlements of the colonisers in these countries. Thus, the pattern seen from the theoretical framework made by the three laureates is that the countries which were richest during the period of colonisation, i.e., where the institutions were set up such that the rich got richer and the poor got poorer, are the ones which are now on the poorer side and have more poverty as compared to the countries where institutions were set up such that there was long term benefit for the population, which are now on the richer side and have rule of democracy.

An interesting case study for this are the cities of Nogales, USA and Nogales, Mexico. The people in both these cities eat the same kind of food, have the same kind of taste in music, have the same ancestry, and yet, people in Nogales, Mexico are poorer than Nogales, USA. This is due to the difference in institutions set up in each country which affects the economy of each city differently. While the citizens of Nogales, Mexico live under the threat of organised crime, those in Nogales, USA have broad political rights and free and fair elections.The reason countries where there were less settlers from European countries, regardless of which European country it was, remain stuck in the loop of the rich getting richer and the poor getting poorer is because the rich elite are not willing to change and challenge the "extractive institutions" which benefit them so. However, when the demands of the larger population stop being met, there can be turning points in such countries so that resistances and revolutions lead to the triumph of democracy over the current elitist regimes.

Their model has three components for bringing about change.

1. *Who holds the decision making power - the elite or the masses?*
2. *Whether the general populace makes their demands heard or not?*
3. *Whether the elite hand over the power to the people? (Which is the only option upon massive resistance from the general populace)*

This follows patterns similar to the revolutions in European countries during the 1700s-1900s.

Simon Johnson



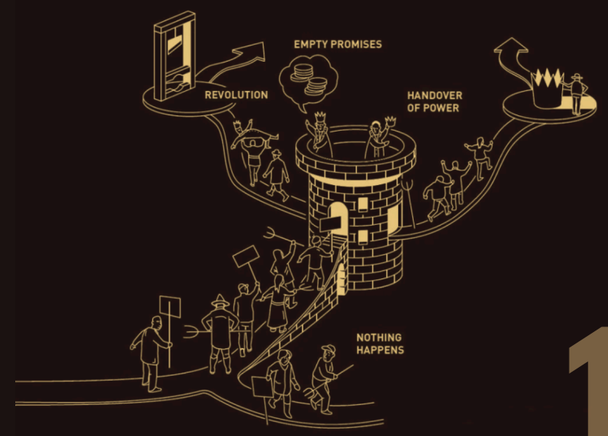
Simon Johnson has been the Ronald A. Kurtz Professor of Entrepreneurship at the MIT **Sloan School of Management** since 2004. He has also served as **Chief Economist** of the **International Monetary Fund**. Author of the 2023 publication, Power and Progress, which addresses the relationship between new technologies and their social and political effects. He is also an avid science fiction fan. "Another hobby of mine is reading science fiction. I have a six page memo of science fiction recommendations and rerank my top 20 science fiction books yearly. Outside of science fiction, I mostly read history."- excerpt from The Tech article 'Meet Simon Johnson, 2024 Winner of Nobel Memorial Prize in Economic Sciences'

James A. Robinson



James A, Robinson is the Rev. Dr. Richard L. Pearson Professor of Global Conflict Studies and a University Professor at the **Harris School of Public Policy** at the **University of Chicago** and directs the The Pearson Institute for the Study and Resolution of Global Conflicts. Boasting an impressive collection of 10,000 books at his home, Robinson himself is the author of several books including 'Why Nations Fail', which he co-authored with Acemoglu.

The Nobel Laureates of Economics have provided a theoretical framework highlighting yet another, and perhaps the most devastating long term effects of colonisation, highlighting that change can only be brought about by people voicing their rights. Their model shows that supporting democracy and inclusive institutions are important in promoting economic development of the world.



LITERATURE

Pravidhi Deshmukh ...

The Science Club organised a talk on the NOBEL PRIZE IN LITERATURE 2024, by Dr. Pooja Sancheti on 2nd December, 2024. Below is a summary of the Nobel Prize winning work.

South Korean novelist and poet Han Kang entered the front rank of world letters on 10 October 2024, when the Swedish Academy announced her as the year's Nobel laureate "for her intense poetic prose that confronts historical traumas and exposes the fragility of human life." She is the first writer in the Korean language—and the first Asian woman—to win the Literature Nobel, and only the second Korean in any category after peace laureate Kim Dae-jung.

At 54, Han is unusually young for the honour; the record remains with Rudyard Kipling, who was 41 when he won in 1907. [1][2]

Storytelling runs in the family. Born in Gwangju in 1970, Han grew up with a novelist father, Han Seung-won, and two novelist brothers, before settling in Seoul—a city that often anchors her fiction. She published her first stories while studying Korean literature at Yonsei University and later broadened her horizons as a participant in the University of Iowa's International Writing Program in 1998—experiences that sharpened her cross-cultural sensibility. [1][2]

Many readers first encountered her through The Vegetarian (2007; Eng. 2015). Deborah Smith's translation made history as the first Korean work to win the International Booker Prize in 2016 and has since travelled into more than forty languages, introducing global audiences to a quietly radical tale of a woman who wishes to become a plant. The novel, like all great works of literature, has multiple layers of interpretation, with the protagonist's arboresque desires portrayed along with mental health, cultural estrangement, sexual and familial violence. [3]

Han Kang explains: "While writing The Vegetarian, I was harboring questions about human violence and the (im)possibility of innocence. On the reverse side of the protagonist Yeong-hye's extreme attempt to turn her back on violence by casting off her own human body and transforming into a plant lies a deep despair and doubt about humanity." [3]

Han's range, however, extends well beyond that slim novel. Human Acts (2014; Eng. 2016) examines the 1980 Gwangju massacre with almost forensic clarity; the hybrid memoir The White Book (2016) circles grief in crystalline fragments; and We Do Not Part (2021) revisits the Jeju massacre and appears in English in February 2025. Short-story collections such as My Name Is Sunflower and the poetry cycle I Put Dinner in the Drawer reveal yet other registers of her voice. Here is what someone whose mother lived through this period had to say about the novel: "This is the power of Han Kang: With little more than paper and ink, she acts as a conduit for the memories of generations that suffered state violence, passing them on to generations that inherited these traumas but not necessarily the long-suppressed facts beneath them. She makes that pain legible, indelible, meaningful. Human Acts forced me to reckon with my inheritance, this formless and weighty thing, to recognize at what cost South Korea's democracy was won. The novel is not a promise to heal all wounds but an invitation to mourn them together." Yung In Chae [5]

In her talk, Dr. Pooja recommended a short story, "The Fruit of My Woman" (https://granta.com/the-fruit-of-my-woman/), translated by Deborah Smith. This is a precursor to The Vegetarian, and as we read a bit of it, you will see one of her key concerns as well as how easily the story speaks to our own experiences. This is an excerpt from the same:

"Because I was tired and hungry, because the crockery was all rusting in the sink's dishpan, without a single clean spoon for me to scoop up some rice, I felt lonely. Because I'd come back to an empty house after travelling such a great distance, because I wanted to talk about all those trivial things that happen on long distance flights, about the landscapes that had scudded past the window on foreign trains, because there was no one to ask 'Are you tired?', robbing me of the opportunity to demonstrate my endurance with a stoic 'I'm okay,' I was lonely. And because of this loneliness, I got angry. Because of the feeling that, owing to my body's insignificance, I was fundamentally unable to enmesh myself within the fabric of this world, because of the chill that was leaching through my suddenly flimsy clothes, and because of the thought that all I had managed in my life so far was to successfully kid myself that I was appreciated, I felt angry. Alone, and with no one to love me, my existence might as well have already been snuffed out.

Just at that moment, I heard a feeble voice.

I turned in the direction of the sound. It was my wife's voice. A faint murmuring carried in from the balcony, impossible to decipher.

Instantly, that intense loneliness morphed into a feeling of relief, and as I stomped over to the balcony I felt a burst of irritation come spiralling off the tip of my tongue. 'Why didn't you answer me if you've been there all this time?' I flung the veranda door open. 'Is this any way to run a household? What on earth have you been living on?'

Then I saw my wife's naked body, and stopped.

My wife was kneeling down, facing the grille that stretched across the balcony window, her two arms raised as though she was cheering. Her entire body was dark green. Her formerly shadowed face now gleamed like a glossy evergreen leaf. Her dried radish-leaf hair was as lustrous as the stems of wild herbs.

Her two eyes glittered pale in her green face. Turning to face me as I shrank back, she shifted as though to get up. But instead, spasms flinched uselessly up and down her legs. She seemed unable either to stand or walk.

Her pliant waist torqued painfully. Her atrophied tongue swayed like a water plant between her deep blue lips. Already, there was no sign of her teeth.

A single cry, little more than a moan, escaped from between those puckering pale-flecked lips.
'. . . water.'" (From "The Fruit of My Woman")



These books arrived already garlanded. At home, Han collected the Yi Sang, Dongri, and Manhae literary prizes; abroad, she claimed honours ranging from Italy's Malaparte to France's Prix Médicis Étranger, confirming critical consensus long before Stockholm called. [2]

Her writing turns on the body as both witness and battleground. Han has argued that "the last line of defense by which human beings can remain human is the complete and true perception of another's suffering," a credo that threads through every page from The Vegetarian to Human Acts.

That ethic shaped her reaction to the Nobel itself. Through her father, she declined the customary victory press conference, saying she could not celebrate "while wars rage in Ukraine and Gaza" and requesting instead a moment of global reflection.

The gesture only intensified interest. South Korean bookshops emptied overnight, online retailers struggled to meet demand, and pre-orders for We Do Not Part surged—proof that a literary prize can still move markets as well as hearts.

For newcomers, The Vegetarian remains the most accessible gateway; those ready for darker terrain can move on to the polyphonic tragedy of Human Acts, while The White Book offers a distilled lyric counterpoint. Whichever path you choose, expect prose that is spare, startling, and profoundly humane—a reminder that literature can still enlarge our capacity to feel for one another.



SCIENCE CLUB
EVENTS ARCHIVE

A LAZY FRIDAY HIJACKED BY CURIOSITY

NATIONAL SCIENCE DAY'25

~Jagadish Parameswaran, Soumyojyoti Pal

Friday, 28th of February, 2025, just another Friday in my 6th Semester. Midsemester break had just hit, and just like any sane person, sleep was my only priority. I woke up directly for lunch, which was around 12 noon, and went and had it.

Visiting Agro was a daily ritual, and today was nothing special. It was at this moment that I noticed the hustle-bustle coming from MDP. Captivated by the crowd, and the huge fans placed in MDP to fight off the scorching heat, I decided to take a 'peek' at the events. Little did I realize that the next 4 hours would be the shortest 4 hours I've ever experienced!

1

First-year wonders with cardboard and clay — who knew biology could be this aesthetic?

Models, Membranes, and Memories

I didn't know where to start; it was all too overwhelming! So many stalls, so much science, and most importantly, so much passion for one's work. Slowly moving towards one of the stalls, I noticed an incredible model of a lipid membrane, followed by models explaining DNA Replication, Central Dogma and Endosymbiont Theory. I later learnt that these were models made by first-years as part of coursework, and was reminded of my awful attempts at art in my first year. Seriously though, the models were splendid in explaining key concepts, and were also incredibly well-made! Moving on from those stalls, I came across toys using the concept of electromagnetic induction, which were very fun to play with.

2

Glasses, light tricks, and pop-science pride—nothing like being dazzled by diffraction.

Polarized and Electrified

All of a sudden, I was caught off-guard by the sight of people wearing whacky glasses and looking at lights. Polarizers! Spending a good deal of time with them, and of course, trying my hands on the classic pop-science trick with 3 polarizers which everyone would've (should've) seen, I moved on to the next stall, with a sense of accomplishment regarding my culture in pop-science.

3

From fossils to future shock — when paleontology becomes a playground and you're schooled by schoolkids.

Extinct Meets Existential

On noticing my friend at the paleontology stall, I quickly headed there, where a guessing game was in full flow! Present-day organisms and their ancestral counterparts were shuffled and placed, and I was asked to pair the animals up. I could get the few easy ones, but was baffled by the rest. Then struck an idea! There were a lot of interested kids ready to try their hands on this game, and I realized this was my best chance to slip off without embarrassment. I did exactly that and was challenged by yet another game, wherein I had to guess which organism gave rise to the fossil, and how it did so. These fossils were placed on the table, and we were allowed to touch them and get a hands-on experience. This time however, I didn't escape from the game, rather I was ousted by some really smart kids. They knew the answers, and more impressively, almost immediately.

4

Handwashing, holography, and qubits — a truly bizarre and brilliant journey through microscopic and quantum realms.

Bacteria, Lasers, and Quantum Whiplash

Speaking of culture, the next stall was about bacterial culture. It showed common methods of experimentation to study bacterial resistance and effects of antibiotics. It demonstrated how the simple act of washing one's hands significantly reduces amount of bacteria, though not entirely, which allowed me to observe for the first time in my life, that 0.1% bacteria from numerous advertisements just chilling on the agar gel. My journey to the next stall was cut short by a laser, which was a setup demonstrating diffraction. With the fringes clearly visible and my inner experimentalist satisfied, I was hit with a sphere, a Bloch Sphere, which is a geometrical representation of the state-space of a two-level quantum system, aka, a qubit. The stall clearly explained the basics of Quantum Computing and left me puzzled with why a cube-it is represented on a sphere (get it!?). With lots of learning from all these stalls, I headed to the next section, ready to explore the remaining 90% of the stalls set up in National Science Day.

5

Glaciers retreating, brains overheating — logic, physics, and the smooth elegance of momentum.

Frozen Talks and Logical Tricks

The explanation was fantastic, and the stall had captivated a ton of students that I knew my time had come to take a break from this crowd. I headed towards the glaciers. I mean, the stall about glaciology. The various zones of the glacier were explained, and the mechanism of a retreat was also explained. It being discussion-oriented was the best part. Following this, I headed to a stall with a logician disguised as a magician. A mind blowing card trick, which is based off the Chinese Remainder theorem was making the heads of various people hurt. Those who were hurt by this shifted to the neighbouring chess stall which posed the classic 8-queen problem, and other fun problems involving chess. Those whose head hurt from this shifted to the card trick stall and thus, the two stalls had people bouncing back and forth with heads hurting.

Bowl-of-rice sorcery and the scientific scalpel — debunking myths with flair and facts.

The Pseudoscience Smackdown

A relief for these patients, including me, was the beautiful demonstration of angular momentum conservation using a looping pendulum. Just sitting back, releasing them, and watching the lighter object twirl countlessly many times around the rod to support the falling heavy object was enough to cure all headache induced by the neighbouring stalls. Not only that, but the science behind such counter-intuitive motion, and questions after tweaking the setup were also extremely fun and engaging discussions. The next stall caught me by surprise! It was a small girl holding a bowl of rice with just a slender object pointed into it. "What is this witchcraft!", said I to myself, and proceeded towards it. Then I saw another girl performing another such trick and was confused as to why they were there in an event which celebrates science. Well, all that I had to do was read their poster, which was how science debunks pseudoscience.

Martian gardens and botanical breakthroughs — school kids reimagine agriculture in alien worlds.

Red Dust and Green Dreams

By now, I had entered the realm of school student's science, where students from various schools present their models and experiments, and I was absolutely not prepared for the level of these experiments and models. I found myself at a stall which questioned life on Mars, and had shown how it could be made possible with some wonderful energy-efficient devices and methods. Hydroponics as a means of agriculture was suggested. I asked them if the difference in gravity would play a role, and they had an answer! Their model also contained all these plants placed in a rotating frame, which uses centrifugal force as a proxy for gravity.

Zooming in on the mundane — discovering beauty and complexity under the microscope.

The World You've Never Seen

Heavily intrigued by their presentation, I moved on to another stall which spoke about creating human tissues from plant tissues. The student not only explained the method succinctly, but also took questions and answered them eloquently. Shortly after this, I found a stall which had a lot of extremely cool-looking images. The intricate patterns and spectacular symmetries in those pictures were mind-blowing. I was asked to guess which everyday objects the pictures are of. Well, to my eyes, they looked nothing like anyone would see in real life! For all I knew at that moment, those images could be AI generated, they were that clean and elegant. Turns out, they were images of daily objects but extremely zoomed in using a microscope, so much that it looked like an entirely new world altogether. I managed to guess a couple of them initially, but as it got harder, the students saw me faulter and they began their laughter.

Children in our current education system are mainly expected to learn what is there and say it all so that the other person feels like you are knowledgeable. This was something I was keen on checking, and therefore ensured questions were asked and discussions were initiated, because that is how science grows. To my surprise, the children were extremely well versed with their projects and models and were able to not only answer questions but were sustaining a discussion, which requires more than just memory. Heavily pleased by this, I kept exploring the other stalls.

Various innovative devices, which were all themed at sustainable energy usage and environment-friendliness, were present. Models tackling niche problems, like death of cattle on railway lines, which is very prevalent in India, were also present, which shows us in how many shapes and forms problems can arise. The students knew how to tackle them; they were all well aware of the phrase 'modern problems require modern solutions'. There were stalls on robotics, where students built interesting robots performing specific tasks. There were stalls with huge tanks of compressed gas, which they used to launch high speed trains. No pressure, railway engineers!

By this time, I was extremely tired, and was being boiled alive in the heat. The huge fan provided some relief, nevertheless, I had to head to Agro for a refreshing drink. On my way, I noticed some wonderful models made by SAC which explain centre of mass. We all have seen those toucans which can balance on their beaks, haven't we? As I checked the time, stunned by how long I had spent at MDP, and how my lazy Friday turned into one of discussion, intrigue and creativity, I headed towards Agro. Well guess what, there were more stalls!

Visual proofs, Napier's magic, and the joy of rediscovering math through models.

Geometry Galore: When Math Becomes Art

An unknown force steered me away from Agro and towards the other stalls that were set up, snatching away my cold-drink dream. These stalls were buzzing like crazy, and I went closer to understand what was going on. These were models of geometry! Students created models to demonstrate visual proofs of the theorems that we derive algebraically in geometry. Yes, same in spirit as the well known advertisement 'A squared plus B squared equals C squared', but levels apart in creativity, and numerous other theorems as well, unlike the advertisement (I have nothing against the advertisement, trust me). There were stalls which showed how easy multiplication could get using Napier Strips. It is always fascinating to see the same operation being carried out in so many different ways, all holding the same underlying principle, but different representations.

Shapes, struggles, and that eureka kick — when puzzles humble you, and you love it.

Tangram Trauma and the Art of Failure

From here I was welcomed by the tangram stall, where I was asked to fill a square or rectangular board completely with various geometrical shapes. Oh how I struggled! These were variants from the more popular tangram puzzles, and I found myself lost in this sea of combinations. The shapes were smartly carved out such that they could fit in multiple, misleading ways, which was the trap I fell into. Admitting my skill issue, I asked for the answer and was immediately shook. When a puzzle you break your head over reveals the answer to you; the kick you get out of that eureka moment is unmatchable. By now, I realized that the stalls were closing soon and I wouldn't even have enough time to explore the stalls set out near the amphitheatre by Aakashganga. Let that sink in, 4 hours not being enough to explore all the stalls!

11

Soap, spheres, and shattered logic — kids' stalls that made your brain pop (and not just bubbles).

Bubbles, Pyramids, and the Death of Assumptions

I was welcomed at the final set of stalls by kids basking under the gifts of an automatic soap bubble generator, and I headed towards it and popped a couple of bubbles myself. Realizing that I was not the target audience, I moved on to the stalls set up. I was offered balls that were joined end to end and was asked to build a pyramid out of them. "Oh that's easy!", said I to myself, and the students, and began my attempt. "Longest piece, should be the base...", said I, as I continue trying various different combinations. To my dismay, I kept failing, repeatedly. By this time, I was worried I wouldn't be able to explore the other stalls, and hence, gave up. The students showed me the answer and I was taken aback! The longest piece ended up being on one of the diagonal edges of the pyramid. My very first step was a mistake :)

12

From solar selfies to the gravity trampoline — where curiosity stretches spacetime (and fabric).

Sunspots and Space-Time Shenanigans

By now there was a lot of excitement brewing at the other side, nearer to the Amphitheatre, from the daytime astronomy stalls of Aakashganga. I headed towards one of them which had captured the image of the sun on a piece of paper, on which a sunspot was clearly visible. It was wonderful to observe, and was even more wonderful to see a lot of young kids who were fully capitalising on their chance to observe something so phenomenal. Right next to this, there was a sundial set up, which alerted me of the severe lack of time I was faced with. Nevertheless, it was great interacting with them and discussing various intricacies of the setup.

13

Like a delicious buffet you couldn't finish — the pain of time's tyranny at a science carnival.

So Much Science, So Little Time

Moving from there, I headed to the next stall, where I learnt about retrograde motion with so much clarity. It was a 2-D geometric model, where the planets could be moved around, to see how the effect appears. Ever since I entered this region of National Science Day, one setup caught my attention. It was the classic spacetime representation on a stretched piece of cloth, denoting how the force of gravity takes birth. This was my time to explore that stall, and hopefully try and understand something out of it. It was fascinating, and of course, extremely satisfying to mildly press the cloth and give in to these intrusive thoughts of pure satisfaction. I've always wanted to do it, and I finally got to do it, yes, I mean, pressing the elastic cloth. As the discussions in this stall kept growing, I was informed that things were closing down! I hadn't even explored everything yet! But what can I do? It's like having extremely tasty food, but a lot of quantity as well, so much that even though you want to, you cannot experience it fully. In the food analogy, it was space in stomach, and in National Science Day, it was time. See, I learnt the connection between space and time! Finally, ending it by taking group pictures of the people organising the Day Time Astronomy Stalls, the time had come to part with this experience. And with a heavy heart, heavy because it is so filled with satisfaction, that I proceeded to the next stall.

Well, the event was over, but some toys and models of Science Activity Centre were still kept on the table, and I used this opportunity to enjoy them. No one was at these stalls, but I got to play with a lot of small but fun setups. Steel beeds falling 'randomly', denoting a random walk, showed the formation of a gaussian distribution. The classic model for explaining precession, using a rope and a bicycle wheel was also available to try. All these, among many other items were there, so many that I can't even remember them now. After a brief exploration of these, my National Science Day experience finally concluded. Well, not yet!

You see, with such an excellent event filling half your day, it is of course natural for it to stay with you. And it did! The memories were so good that it stayed deep in my heart, until they were brought to life through this article, thanks to Helicase being reborn! I hope this article made you regret missing National Science Day 2025 (if you didn't actually miss it, good for you!), and thereby, forces you to attend (or even better, participate!) in National Science Day 2026. I also hope this article has convinced you that National Science Day is one of the most fun events that happen in college, because very evidently, the science(signs) are real!



THINK LIKE AN inventor.

~Anandita Chandran

The second week of April is a time the IISERP student community finds itself scurrying about in an attempt to wade through the academic flood an upcoming end-semester season brings with it. In the midst of this frantic pressure, Prof**. Sivakumar M. Srinivasan**'s workshop offered a brief breath of fresh air in the form of a refreshing new perspective. Titled '**Think Like An Inventor**', Prof. Srinivasan conducted this workshop series in different parts of India to encourage students not to tie learning to grade boundaries and take the extension to look at what experiences can teach.

He believed the one who makes a difference in this world would, naturally, be an inventor - someone who comes across a problem, has empathy for it, and comes up with a solution. To illustrate the beauty behind an invention, a new thought, he put forth his ideas through a (success) formula he'd come up with: '**7 Habits of an Inventor**' - each habit skillfully describing each facet of what it means for a person to be an 'inventor'.

Habit 1: FOUND
This handy mnemonic explains the story lending to an invention

F **Fun** activity/experiment → Something we do

O **Observation** → where is the gap? Is something wrong? Can something be better?

U **Understanding** → what can i do to help? How can this be fixed?

N **Noticing applications** → where else can this be used?

D **Discovery** → An Aha! moment, this is how to help the public

Habit 2: Open your eyes! Observation is really the only key to learn concepts and identify solutions

Habit 3: Build an intuition, understand the underlying details of how things work

Habit 4: Testing, testing, and some more testing! Trial and error is the true constant

Habit 5: Question the past before speculating about the future - Ask have already been done here?

Habit 6: Connect with day to day activities, you don't need a fancy bag of tricks - keep it simple

Habit 7: Get inspired! To truly be an inventor, you have to put yourself not in the shoes, but the mind of one

The workshop wasn't just him lecturing on this theory, Prof. Srinivas used bountiful examples from real everyday lives, right from the transportation of the famous Ice House from the UK to Chennai (frozen and intact!) to Rahul Panicker and Jane Chen's NICU incubator for preemie babies, he let the actions speak for themselves. His own story is ingrained with the principle he attempts to put across - deeply saddened on hearing the mounting cases of Indian university students committing suicide in their hostel rooms, he built an anti-suicide ceiling fan, fitted with an elastic spring in the down rod that would automatically make the fan fall down front he ceiling on sensing the additional weight should someone attempt to hang themselves. What an epitome of the FOUND habit!

He also urged students to look beyond traditional boxes, and ferry transport ideas across disciplines and industries. Chocolate and chip packets have serrated edges to help with quick tearing. That led to the invention of easy-tear tape - featuring in-built perforations, meaning you don't need scissors anymore! Hydroxyapatite is arranged as small fragment elements in the bone which makes the structure stronger and reduces space for defects. That led to the invention of making the tip of car windshield cracks blunt to prevent stopover spreading!

Between Prof. Srinivas's cheery demeanour, nimble movements, riveting anecdotes, and the ample food for thought questions he sprinkled throughout, students were glued to their seats, spellbound by this new direction of thinking, and three hours of passionate discussion just flew by in a blur! Science Club is genuinely grateful Prof. Srinivas reached out to us with an interest to conduct this workshop in IISER Pune. What a wonderful opportunity and hopefully the start of the invenion of a new generation of inventors. To conclude with a quote from the man himself,
"Live for the experience and leave behind at least one invention. Make it happen."



Sivakumar M. Srinivasan
HOD & Professor, IIT Madras

HELICASE *Fall Edition, 2025*

DARKNESS GLOWING SOFTLY

The Incredible Story of Black Holes

~Suhani Bhattacharyya

SUNIL MUKHI



I was in the lab, and realised I had to 2 hours to kill while waiting for my experiment to run. What to do? Duolingo and Instagram were giving me a headache. So, fortunately, I decided to scroll through my emails. There was a reminder from Science Club about Prof. Sunil Mukhi's talk on black holes. My friends had been telling me that they were all going to attend it and I thought, 'Well, why not?' and proceeded to LHC 101.

What are black holes? As described by NASA, "A black hole is an astronomical object with a gravitational pull so strong that nothing, not even light, can escape it". Prof. Mukhi's was a non-technical talk (to my relief as a biologist with no prior knowledge about this subject) about the history of black holes. In easy-to-understand language, Prof. Mukhi was able to convey the remarkable origins of black hole research, explaining how earlier these were thought to be unphysical artefacts of General Relativity, but have now become established objects abundant in our universe. Not only do they distort the fabric of space and time, but their existence seems to challenge the laws of thermodynamics (which were fresh in my head thanks to the previous semester course, otherwise the only option was to look like a fool in front of my physics major friends, but that would be ok, because most of them didn't know what the central dogma was) since they seem to swallow matter and energy, so that entropy for the closed system seems to decrease. However, it is now known that they carry an intrinsic entropy, such that, the net entropy for the system increases. This point was explained eloquently by Prof. Mukhi as he took the audience through a journey about black hole research highlighting the pioneering works of A.K. Raychaudhuri, Roger Penrose (who won the Nobel Prize in Physics for this work in 2020) and Stephen Hawking.

Prof. Mukhi further elaborated on recent research highlights and future directions for black hole research. Followed by this talk was one of the most interactive Q&A sessions I have ever attended with Prof. Mukhi patiently explaining and answering the questions of those with expertise in the subject as well as for those who did not. Prof. Mukhi's insightful words had entranced me so, that as the talk wrapped up I had to remind myself that I had an experiment in the lab to get back to and I simply could not go down get pulled down an internet black-hole about black holes (I was also reminded of this by my alarm ringing, which was thankfully drowned out by the sound of the almost fully-packed room leaving).

We were all incredibly grateful to Prof. Mukhi for working his magic to provide an accessible talk on an incredibly complex topic to the students of IISER Pune and hope he continues to do so in the future.







THE FAULT IN OUR EXPLODING STARS?

~Anargha Mondal

The **European Space Agency** is responsible for monitoring the *Planck mission*, probably one of the most important space laboratories that humankind has ever made. What it does is essentially take **extremely high definition pictures of the universe** as a (*thermalised*) baby. Well, a 380,000 year old baby, but that is quite besides the point. These **billion pixel** maps help us calculate all sorts of important parameters and statistics pertaining to our best model for the universe - **the Lambda CDM model**. One of these parameters, called the **Hubble Constant**, tells us how fast the universe is expanding *today*. Planck estimates this number to be about 67.4 *km/s/Mpc*, where *Mpc* is a measure of distance (roughly 3.26 million light years). The observations matched exceptionally well with the predictions from the Lambda CDM model, and it was all smooth sailing.

But physics, like life, is not all roses and sunshine. Astrophysicists started facing a problem when they tried to investigate the same question from the other way round: using a picture of the late-time (read: recent) universe, can we compute how fast the universe is expanding today? And indeed we can, using well-studied 'lighthouses' called **standard candles** to measure cosmic distances. But instead of getting the same values as the Planck measurements, we got something **slightly higher**: around **73 km/s/Mpc**, with only a *1% margin of error*. This seems to make little sense, and is one of the most prominent problems in cosmology today. Upholding their tradition of *underwhelming nomenclature*, cosmologists and astrophysicists termed the problem as the '**Hubble Tension**'.

My work over the summer of 2024 was to take a closer look at these standard candles—specifically, **Type Ia Supernovae**, which are the fantastically bright aftermaths of white dwarfs reaching their final limit and deciding, quite dramatically, that they've *had enough*. These stars explode only after reaching a well-defined critical mass—the **Chandrasekhar limit**—which means their *intrinsic brightness* is, conveniently, *very predictable*. This makes them perfect tools for measuring cosmic distances, and by extension, estimating the Hubble Constant.

Of course, nothing in astrophysics is ever as simple as "*just measure it*". The devil is in the details—or in this case, in the *dataset* and the *statistical analysis*. The accuracy of our results depends on how the supernovae are selected, how the redshift bins are chosen, and how the brightnesses are calibrated across different surveys and cosmic epochs. Subtle effects—like host galaxy properties or interstellar dust—can nudge results in just the right way to mimic new physics, even if none exists. And yet, the numbers stubbornly persist.

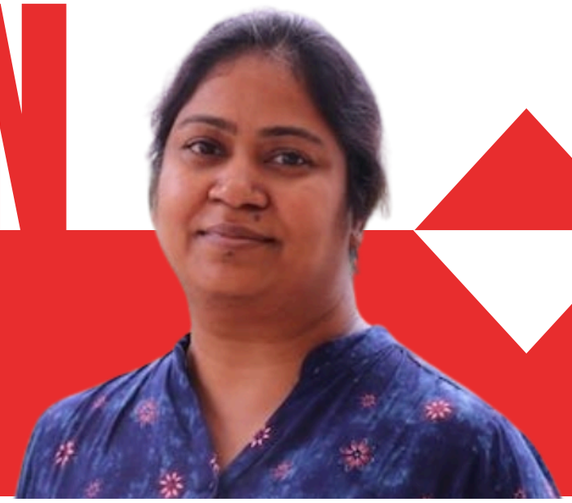
This was the crux of my talk for the *Science Club* on the **14th of November, 2024**. We explored the possible sources of this so-called '***tension***'—from overlooked astrophysical biases to genuinely new physics—and surveyed some of the increasingly creative theories the cosmology community has put forward over the past few years. Whether the solution lies in tweaking the model, refining the data, or rewriting part of what we think we know about the universe... well, that part's still unfolding.

HELICASE *Fall Edition, 2025*

HIGGS BOSON TALK SERIES



Diptimoy Ghosh
How did we find it?

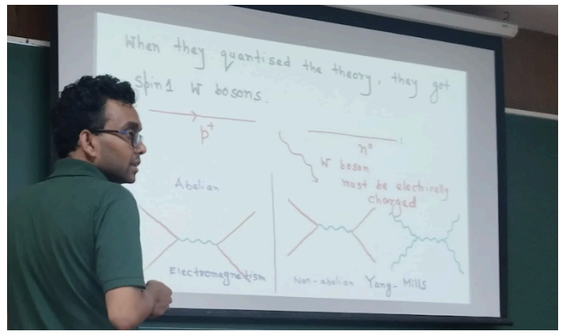


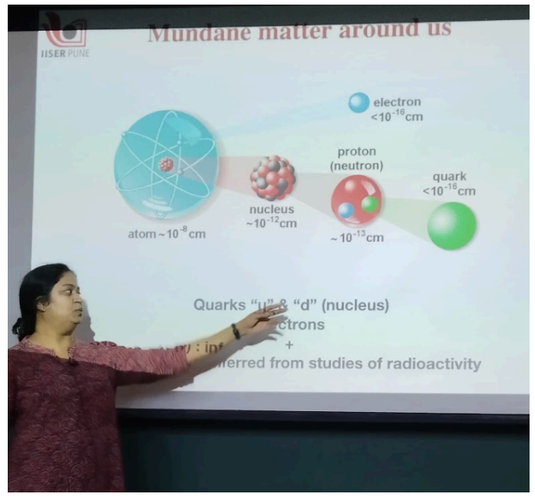
Seema Sharma
Why do we need it?

The **Higgs Boson** is named after **Peter Higgs**, who predicted the existence of a mass giving Field and its corresponding particle in 1964 which was eventually named after him. The Higgs Boson was experimentally observed in 2012 by the ATLAS and CMS experiments at the Large Hadron Collider at CERN. The Higgs Boson is the only fundamental Spin 0 particle discovered to date and one of the few self-interacting particles found in nature. Over two enlightening days, Dr. Seema Sharma and Dr. Diptimoy Ghosh delivered two insightful talks on this Majestic, Massive, Mass-giving particle.

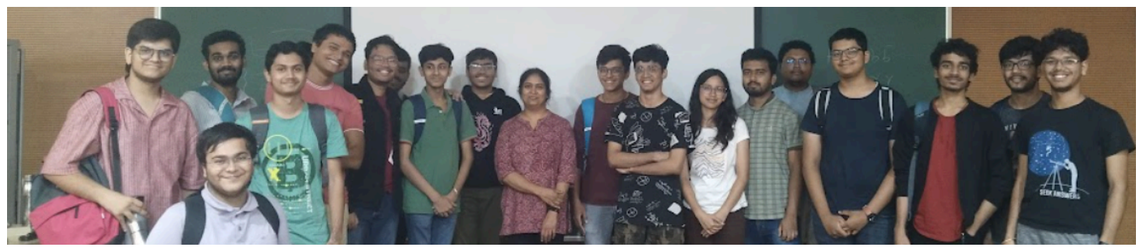
On day one, Diptimoy Ghosh delved into the theoretical aspects of the only scalar boson discovered to date. The talk explained the context behind the proposal of the Higgs Field and the Higgs Mechanism and the Higgs Boson as a Scalar Boson. The talk then explained the Sombrero potential of the Higgs Field and the phenomenon of spontaneous symmetry breaking which is responsible for providing a rest mass to particles. Dr. Ghosh's talk was very detailed and the Q&A that followed was jargon-full and intense.

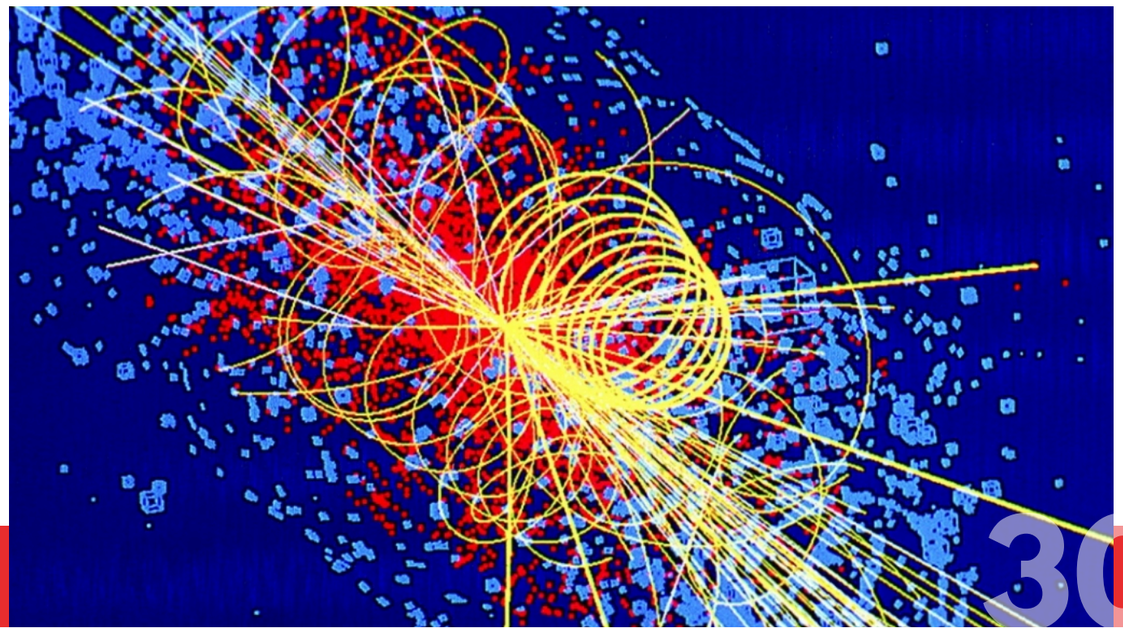
On day two, Seema Sharma covered the experimental aspects of the elusive particle, delving into the data and explaining the achievement of the first observation of this mass-giving particle. The talk explained the groundwork laid by previous experiments exploring and eliminating energy regimes in search of the Higgs succeeded by the Large Hadron Collider (LHC) which was designed to probe more energy regimes, leading to the first observation of the Higgs Boson. The Higgs Boson is highly unstable and thus can only be detected indirectly through its decay into other subatomic particles. The talk went over the different decay paths of the Higgs Boson and the advantages of probing specific paths for observation. The talk then covered the experimental challenges of the observation and discussed the noise produced by various sources and the measures taken to minimise these contributions. It also went on to discuss current experimental efforts to probe plausible interactions of the Higgs including its self-interaction. The talk also covered the metastable nature of the Higgs Field and the current experimental evidence relating to it. Dr. Sharma delivered an engaging talk that was very beginner-friendly and garnered questions not only during the Q&A that followed but also during the talk all of which were answered simply and precisely by our esteemed speaker.





~ Pranshu Nemani





NritTarang



Can a river feel, just as it can flow? Can a river rage, just as it can raze? And, suppose it does raze - does it deserve punishment, just as we do? While these may be foreign concepts in everyday matters- ones that value a scientific, 'logical' evaluation over an artistic one- these notions are adopted easily and accepted more easily in ancient art forms such as Bharatanatyam. ***Dr. Radhika Mulay***'s talk on the rights of rivers deals with this very thought; a water researcher by day, and professional Bharatanatyam dancer by night, both her careers find their confluence in this probing question.



The story starts further off from home- the banks of the Whanganui River, New Zealand, in 2017- the second river in the world to be granted a legal status as a living entity. An identity armed "with all the corresponding rights, duties and liabilities of a legal person" was conferred upon it to settle legal disputes, and the stewardship of its rights vouchsafed to the Maoris.

However, this raises uncomfortable questions. Can such a status be meaningfully applied to what is widely perceived as a non-living entity, especially in India? If a river has rights, what appropriate duties should it uphold? Whose jurisdiction does a trans-boundary river fall under? Who defends its rights, once they have been defiled, and what is the appropriate institutional punishment for a river if it floods and massacres the surrounding land?

In Bharatanatyam pieces, the anthropomorphism of non-human bodies is standard practice- a depiction of the Ganga flooding her banks in fury is extolled by the same audience that will gainsay even the proposal that a river might be living, let alone legal. Other than the admission that art is valued less than cold, hard science, Mulay points to a deeper-rooted issue- the fundamental inability of people to empathise with and relate to objects, something that Bharatanatyam has threaded through the very fabric of its being, via abhinaya. Her perspective is an interesting one- all forms of art are knowledge systems. Perhaps a furious Ganga flooding its banks functions both as a story and a lesson for its onlookers.

In today's political framework, especially in a world where there are clamors for facts and figures before imagination, perhaps it is not a question of art vs science, but of learning to listen when both speak at once.

~ Srishti Kar



MS THESIS SHENANIGANS

~ Rupsa Chatterjee

APR 09, 2024



SUMANT CHOPRE

Credit Risk Estimation Using Various Graphs

Sumant presented a novel approach to credit risk estimation using graph-based methods. By treating cust-omers as nodes and connecting them through shared personal information, he developed a graph-based feature extraction framework. This method enhances predictive power even for individuals with sparse credit histories, a demographic that often poses challenges for traditional ML models.

APR 11, 2024



ADITYA SHUKLA

Application of Multiscale Simulation for Battery Materials

Aditya explored how multiscale computer simulation methods can unravel the complex manufacturing processes of lithium-ion batteries. His research identifies how various controllable parameters affect battery output, bridging the gap between empirical manufacturing practices and theoretical understanding.

APR 12, 2024



HARSH DOSHI

Segregation Kinetics of Topologically-Modified (DNA) Polymers in Confinement

Harsh discussed entropic mechanisms that allow chromosome segregation in rod-shaped bacteria, even in the absence of active machinery. Using polymer simulations, he explored how architectural modifications of polymers affect the process, laying groundwork for under-standing biophysical phenomena in constrained environments.

APR 13, 2024



VIVEK SABARAD

NMR Quantum Kernels Enable Machine Learning with Quantum Data

Vivek presented his experimental implementation of quantum kernel methods on a 10-qubit NMR register. His extended framework efficiently classifies quantum operators and demonstrates promising extrapolation abilities, marking significant progress in integrating quantum computing with classical ML tasks.

APR 13, 2025



SARANSH AGRAWAL

Assessing the consequences of using "black-box" AI models in science

In a deeply philosophical talk, Saransh questioned the epistemic validity of using black-box AI/ML models in scientific inquiry. Drawing from scientific epistemology, he argued for a systematic and accessible framework to understand the role of explanation in AI-driven predictions.

APR 14, 2025



PAARTH DUDANI

Neural Network-Based Pipeline to Improve Gene Regulatory Network Inference

Paarth proposed a neural-network-based alternative to Bayesian methods like MCMC for inferring gene regulatory networks. His approach promises faster yet reasonably accurate results, enhancing applications in systems and synthetic biology.

APR 15, 2025



KESHAV V

Quantum Dynamics and Control of Reconfigurable Rydberg Atom Arrays

Keshav explored the control and manipulation of Rydberg atom arrays using adiabatic annealing and dynamic rearrangement. His novel protocol deviates from traditional Landau-Zener dynamics and proposes analytic solutions, advancing both theoretical and experimental quantum simulation.

APR 16, 2025



MANAS RAIKAR

Neuromesodermal Progenitor Contributions to Neural Crest Derivatives

Manas challenged conventional understanding of embryonic development by uncovering neuromesodermal progenitors as a novel source for neural crest derivatives. His findings significantly expand the known developmental potential of embryonic cell populations.

APR 14, 2025



DEVADHARSHINI L T

Trading Strategy for Equity Market and F&O

Devadharshini applied 1D CNNs and XGBoost to financial data, proposing hybrid AI strategies for stock market prediction. With a comparative study of sector rotation models like FF3, her research points toward data-driven, robust models for Indian financial markets.

APR 15, 2025



ANIKET SENGUPTA

Partial Quantum Shadow Tomography

Aniket introduced the concept of quantum shadow tomography, a method to estimate quantum states with minimal measurement. He illustrated the elegance and practicality of this method with experimental results, offering a glimpse into efficient quantum diagnostics.

APR 17, 2025



SUMIT GHOSH

Distributed Acoustic Sensing Using an Ultra-stable Laser

Sumit presented advancements in Distributed Acoustic Sensing using ultra-stable, narrow-linewidth lasers. His system offers enhanced sensitivity and spatial resolution, applicable in geophysics, structural monitoring, and surveillance.

APR 17, 2025



KAUSTUBH KULKARNI

From Linking Patches to Linking Theories: Cooperation in Metapopulations

Kaustubh demonstrated how spatial structure in metapopulation models can stabilize cooperation despite ecological fragility. His talk bridged concepts from theoretical ecology and evolutionary dynamics, linking patch dynamics to broader metacommunity theories.

APR 18. 2025



HARRSH GOYAL

6D Phase Space Characterisation of a Muon Beam for Measuring the Muon's EDM

Harrsh explained the physics and experimental intricacies behind the muEDM experiment, which seeks to measure the muon's electric dipole moment with unprecedented sensitivity. His work focuses on phase-space characterization of the muon beam, offering potential insights into CP violation beyond the Standard Model.

APR 18. 2025



ABHAYKRISHNAN

NRPS Engineering of Epoxyketone Proteasome Inhibitors

Abhaykrishnan shared his synthetic biology efforts to engineer NRPS pathways for enhanced production of epoxyketone compounds like epoxomicin. These compounds hold promise as anti-cancer agents and his talk detailed the rational design strategies used to improve their bioactivity.

APR 19. 2025



PRABHAV KUMAR

Semi-Transparent Solar Cells for Agri-Voltaic Application

Prabhav introduced semi-transparent organic solar cells designed at IISc for agri-voltaics. Unlike traditional silicon-based PVs, these cells allow light penetration for plant growth while generating electricity—demonstrated using Arabidopsis thaliana as a model system.

APR 20. 2025



OYNDRILA SAMANTA

Cyanobacterial biochemistry using -omics and cell-free systems

Oyindrila explored the biochemical diversity of cyanobacteria using high-throughput techniques such as metabolomics and proteomics. Her work focused on understanding carbon fixation and photosynthetic metabolism, with implications for sustainable biosynthesis under climate change.



PANEL DISCUSSION



YouTube Recording

The Impact of AI in Science Education and Research

~Rudra Sahu ...

June 01, 2025

To engage with the evolving discourse surrounding artificial intelligence (AI) and its implications in academia, The Science Club at IISER Pune hosted a panel discussion titled "***The Impact of AI in Science Education and Research at IISER Pune***". The event brought together esteemed faculty members, **G. Nagarjuna** (*Science Education*), **Nagaraj Balasubramanian** (*Biology*), and **Sunil Mukhi** (*Physics*), for a thoughtful exploration of how AI is reshaping the landscape of scientific inquiry and pedagogy. The session was moderated by **Saransh Agarwal**, a graduating BS-MS student of IISER Pune.

The discussion opened with reflections on the broader historical context of technological revolutions. Prof. Mukhi highlighted the parallels between the internet's transformative impact and the current wave of AI integration, cautioning that while access to knowledge has expanded, deep engagement and retention may be declining. He emphasised the need for individuals to define larger intellectual goals, noting that while AI can perform many tasks efficiently, the uniquely human ability to set meaningful scientific objectives and exercise imagination remains irreplaceable.



Sunil Mukhi
Physics

Prof. Balasubramanian focused on the challenge of maintaining critical thinking in an age of instant answers. He emphasised that AI tools, while powerful, risk fostering complacency if users rely on them uncritically. He underlined the importance of adaptability, as the rapid pace of AI development demands continuous re-evaluation of teaching strategies, assessment models, and institutional structures. He also raised concerns about the influence of AI on motivation and originality, advocating for stronger integration of reflective and interdisciplinary learning.



Nagaraj Balasubramanian
Cell Biology

Prof. Nagarjuna examined the philosophical and educational dimensions of AI's rise. He described the shift from passive content consumption to active engagement with AI agents as a "**paradigm change**" in human-machine interaction. He noted the importance of redesigning teaching models to focus less on content delivery and more on meta-skills, such as learning how to engage with, question, and critically evaluate content. He advocated for project-based learning environments supported by AI as co-pilots, enhancing student agency and fostering a more dialogic approach to education.



G. Nagarjuna
Science Education



The panel also discussed institutional implications, including the need to reassess large-class formats, rethink assessment strategies, and prioritize spaces for in-person intellectual exchange. The speakers strongly emphasised that physical interactions, informal discussions, and spontaneous encounters remain vital for cultivating creativity and scientific culture, dimensions that AI cannot replace.

In the Q&A, the panel explored ethical usage of AI, the role of teachers as facilitators rather than information deliverers, and the necessity of teaching students to ask better questions and recognize hallucinations in AI outputs. All three panelists agreed that while AI presents tremendous opportunities, its integration into education must be intentional, reflective, and aligned with the core values of inquiry and mentorship.

The session concluded with a call for continued dialogue, interdisciplinary collaboration, and proactive policy-making within academic institutions to harness AI's potential while safeguarding the human essence of education and research.

SCIENCE IN YOUR BACKYARD



1st

Amish Butle

DE NOVO ROOT REGENERATION..The image shows a type of regeneration adapted by plant for their survival where in roots are emerging out of a leaf. The cells of leaf have undergone process of de-differentiation and re-differentiation to form roots cells for the survival. In latin "de novo" stands for "make from scratch" where in leaf cells which are mostly photo ynthetic in nature earlier , now have taken a fate of cells which will help in absorption of water which is root cells. Plant model organism used here is *Arabidopsis thaliana*.

2nd

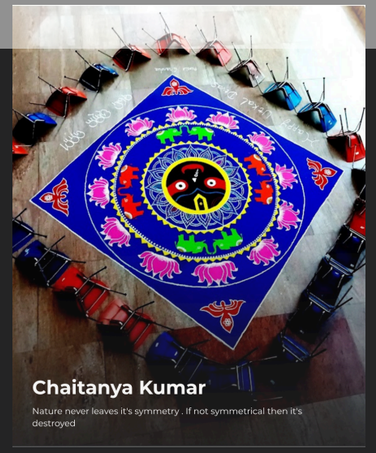
Munish Gakhar

What looks like streaks of stars across the sky is actually a time-lapse of Earth's rotation. Captured from the ground over several hours, this image reveals the circular paths traced by stars as our planet spins on its axis (also known as Star Trails), a stunning reminder that we're always in motion, even when we stand still. Science isn't just in labs sometimes, it's right above our heads.

3rd

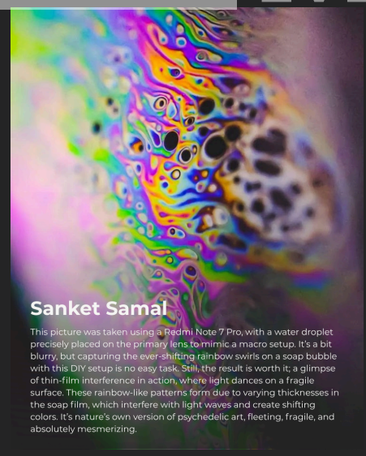
Dilip V

Captured from the IISER Main Academic Building using a Nikon COOLPIX P900, this image underscores how accessible tools can contribute to solar observation.
This image, captured on 19th January 2025, reveals a striking view of the sun with multiple sunspot clusters visible across its surface. Sunspots—cooler, magnetically active regions on the sun—are key indicators of solar activity. The large cluster near the solar equator (northern hemisphere) and four smaller groups at mid-latitudes provide critical data for studying the sun's differential rotation: the equator rotates faster (~24 days) than higher latitudes (~35 days). By tracking the daily movement of these sunspots relative to Earth, astronomers calculate rotation rates and monitor changes in solar dynamics.
Their distribution also aligns with the solar cycle; sunspots peak during solar maximum (every ~11 years) and diminish during minimum. The prominence of these clusters suggests heightened solar activity, offering insights into space weather and its potential impacts on Earth's technology.



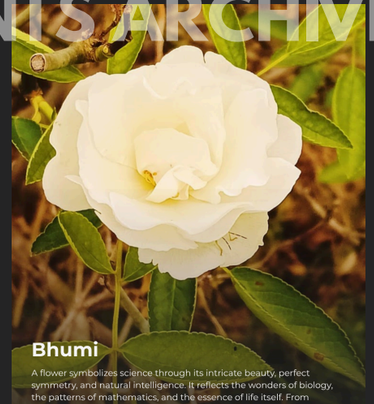
Chaitanya Kumar

Nature never leaves it's symmetry . If not symmetrical then it's destroyed



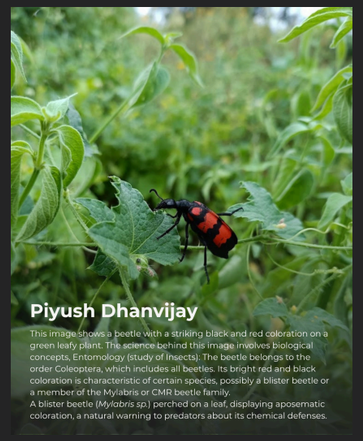
Sanket Samal

This picture was taken using a Redmi Note 7 Pro, with a water droplet precisely placed on the primary lens to mimic a macro setup. It's a bit blurry, but capturing the ever-shifting rainbow swirls on a soap bubble with this DIY setup is no easy task. Still, the result is worth it; a glimpse of thin-film interference in action, where light dances on a fragile surface. These rainbow-like patterns form due to varying thicknesses in the soap film, which interfere with light waves and create shifting colors. It's nature's own version of psychedelic art, fleeting, fragile, and absolutely mesmerizing.



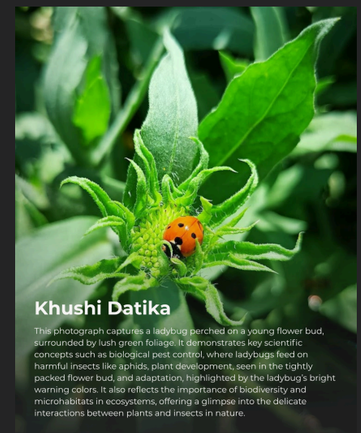
Bhumi

A flower symbolizes science through its intricate beauty, perfect symmetry, and natural intelligence. It reflects the wonders of biology, the patterns of mathematics, and the essence of life itself. From genetics to ecology, a flower is nature's elegant blueprint—uniting curiosity, complexity, and discovery in every delicate petal.



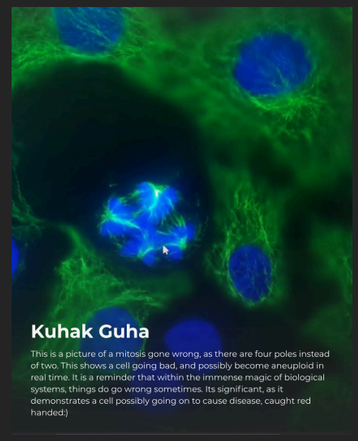
Piyush Dhanvijay

This image shows a beetle with a striking black and red coloration on a green leafy plant. The science behind this image involves biological concepts, Entomology (study of Insects). The beetle belongs to the order Coleoptera, which includes all beetles. Its bright red and black coloration is characteristic of certain species, possibly a blister beetle or a member of the Mylabris or CMR beetle family.
A blister beetle (*Mylabris sp.*) perched on a leaf, displaying aposematic coloration, a natural warning to predators about its chemical defenses.



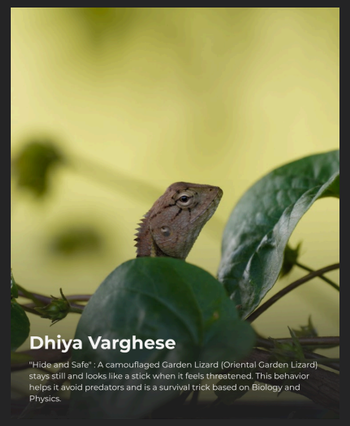
Khushi Datika

This photograph captures a ladybug perched on a young flower bud, surrounded by lush green foliage. It demonstrates key scientific concepts such as biological pest control, where ladybugs feed on harmful insects like aphids, plant development, seen in the tightly packed flower bud, and adaptation, highlighted by the ladybug's bright warning colors. It also reflects the importance of biodiversity and microhabitats in ecosystems, offering a glimpse into the delicate interactions between plants and insects in nature.



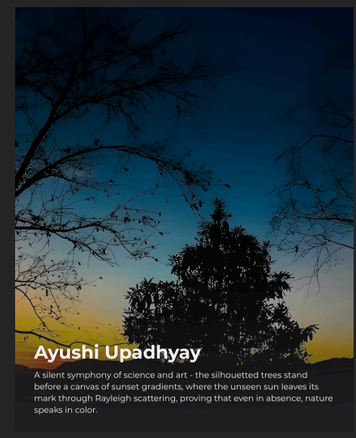
Kuhak Guha

This is a picture of a mitosis gone wrong, as there are four poles instead of two. This shows a cell going bad, and possibly become aneuploid in real time. It is a reminder that within the immense magic of biological systems, things do go wrong sometimes. Its significant, as it demonstrates a cell possibly going on to cause disease, caught red handed:)



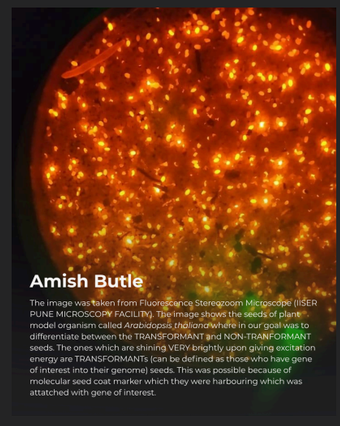
Dhiya Varghese

"Hide and Safe" : A camouflaged Garden Lizard (Oriental Garden Lizard) stays still and looks like a stick when it feels threatened. This behavior helps it avoid predators and is a survival trick based on Biology and Physics.



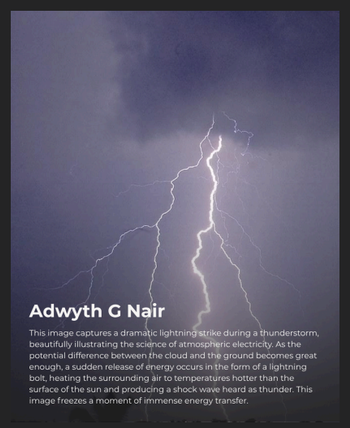
Ayushi Upadhyay

A silent symphony of science and art - the silhouetted trees stand before a canvas of sunset gradients, where the unseen sun leaves its mark through Rayleigh scattering, proving that even in absence, nature speaks in color.



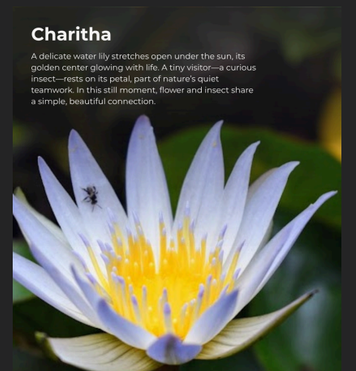
Amish Butle

The image was taken from Fluorescence Stereozoom Microscope (IISER PUNE MICROSCOPY FACILITY). The image shows the seeds of plant model organism called *Arabidopsis thaliana* where in our goal was to differentiate between the TRANSFORMANT and NON-TRANFORMANT seeds. The ones which are shining VERY brightly upon giving excitation energy are TRANSFORMANTs (can be defined as those who have gene of interest into their genome) seeds. This was possible because of molecular seed coat marker which they were harbouring which was attatched with gene of interest.



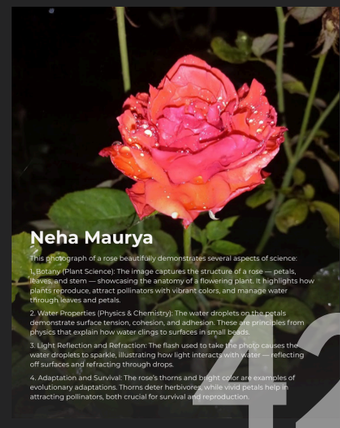
Adwyth G Nair

This image captures a dramatic lightning strike during a thunderstorm, beautifully illustrating the science of atmospheric electricity. As the potential difference between the cloud and the ground becomes great enough, a sudden release of energy occurs in the form of a lightning bolt, heating the surrounding air to temperatures hotter than the surface of the sun and producing a shock wave heard as thunder. This image freezes a moment of immense energy transfer.



Charitha

A delicate water lily stretches open under the sun, its golden center glowing with life. A tiny visitor—a curious insect—rests on its petal, part of nature's quiet teamwork. In this still moment, flower and insect share a simple, beautiful connection.



Neha Maurya

This photograph of a rose beautifully demonstrates several aspects of science:

1. Botany (Plant Science): The image captures the structure of a rose — petals, leaves, and stem — showcasing the anatomy of a flowering plant. It highlights how plants reproduce, attract pollinators with vibrant colors, and manage water through leaves and petals.

2. Water Properties (Physics & Chemistry): The water droplets on the petals demonstrate surface tension, cohesion, and adhesion. These are principles from physics that explain how water clings to surfaces in small beads.

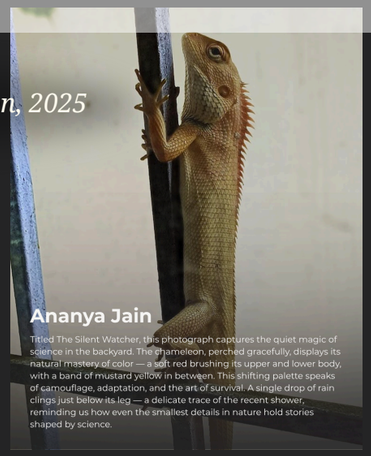
3. Light Reflection and Refraction: The flash used to take the photo causes the water droplets to sparkle, illustrating how light interacts with water — reflecting off surfaces and refracting through drops.

4. Adaptation and Survival: The rose's thorns and bright color are examples of evolutionary adaptations. Thorns deter herbivores, while vivid petals help in attracting pollinators, both crucial for survival and reproduction.



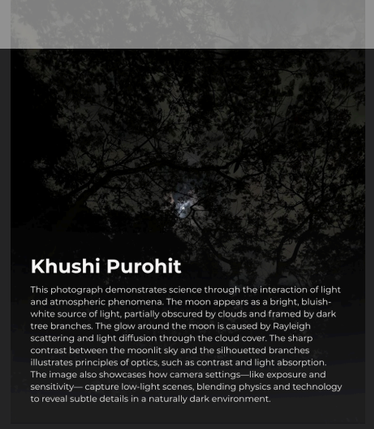
K Aparna

this picture was taken during a quiet summer evening; the beautifully lit IISER campus was shining in the backdrop of the evening sky with warm pink tones due to the setting sun (lesser scattering of red light gives rise to these hues) and with fluffy cumulus clouds (seen more prominently during summers due to the formation of large pockets of hot air that rise up and condense to form theseclouds) adorning it.



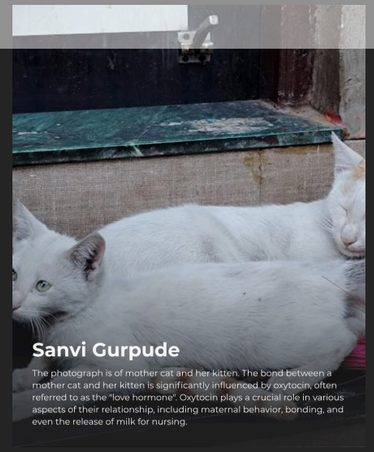
Ananya Jain

Titled The Silent Watcher, this photograph captures the quiet magic of science in the backyard. The chameleon, perched gracefully, displays its natural mastery of color — a soft red brushing its upper and lower body, with a band of mustard yellow in between. This shifting palette speaks of camouflage, adaptation, and the art of survival. A single drop of rain clings just below its leg — a delicate trace of the recent shower, reminding us how even the smallest details in nature hold stories shaped by science.



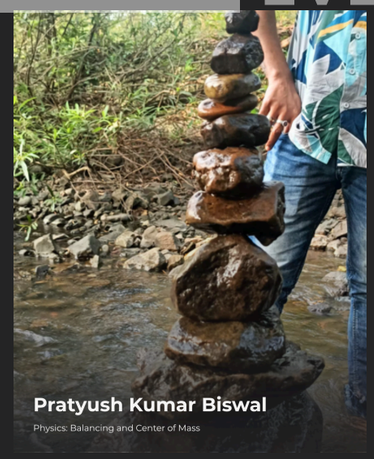
Khushi Purohit

This photograph demonstrates science through the interaction of light and atmospheric phenomena. The moon appears as a bright, bluish-white source of light, partially obscured by clouds and framed by dark tree branches. The glow around the moon is caused by Rayleigh scattering and light diffusion through the cloud cover. The sharp contrast between the moonlit sky and the silhouetted branches illustrates principles of optics, such as contrast and light absorption. The image also showcases how camera settings—like exposure and sensitivity— capture low-light scenes, blending physics and technology to reveal subtle details in a naturally dark environment.



Sanvi Gurpude

The photograph is of mother cat and her kitten. The bond between a mother cat and her kitten is significantly influenced by oxytocin, often referred to as the "love hormone". Oxytocin plays a crucial role in various aspects of their relationship, including maternal behavior, bonding, and even the release of milk for nursing.



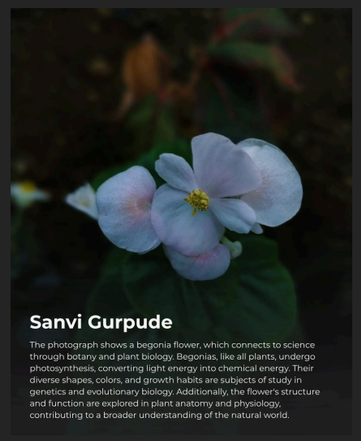
Pratyush Kumar Biswal

Physics: Balancing and Center of Mass



Pratyush Kumar Biswal

Message from God: Path of light visible in a colloid solution (Rainy day)



Sanvi Gurpude

The photograph shows a begonia flower, which connects to science through botany and plant biology. Begonias, like all plants, undergo photosynthesis, converting light energy into chemical energy. Their diverse shapes, colors, and growth habits are subjects of study in genetics and evolutionary biology. Additionally, the flower's structure and function are explored in plant anatomy and physiology, contributing to a broader understanding of the natural world.



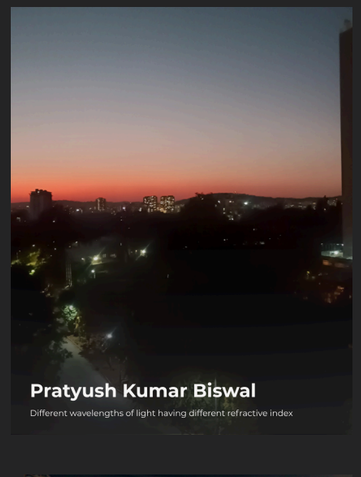
Vansh Pathak

This photograph captures raindrops clinging to a glass window which is clicked on Motorola Edge 50 Fusion that showcases several scientific phenomena.
1) The near-spherical shape of the droplets is caused by surface tension by balancing cohesive forces within the water and adhesive forces with the glass.
2) Each droplet acts as a tiny convex lens of water which refracts light in such a way that it inverts and focuses some fraction of the background behind the glass which is blurry in the image.
3) The droplets also are bright due to partial internal reflection of light from the light bulbs which are behind the camera.
4)The camera was positioned close to the droplets and focused on them, resulting in a shallow depth of field that blurred the background.
5) The soft and diffused light from the sky avoids harsh shadows which helps in achieving a moody image.



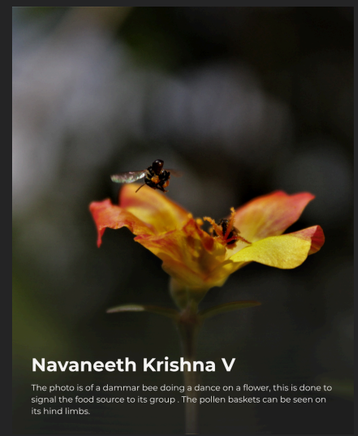
Sanvi Gurpude

The photograph shows a barn owl (Tyto alba) perched on a window sill. Barn owls are signifcant in scientific research, particularly in the fields of sensory systems, ecology, and behavior.The barn owl is a member of the owl family, and its extremely sharp vision and hearing allow it to hunt in total darkness. Researchers can use the barn owl to learn about attention, both in animals and humans.



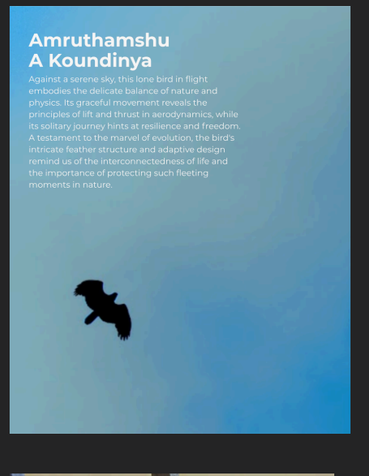
Pratyush Kumar Biswal

Different wavelengths of light having different refractive index



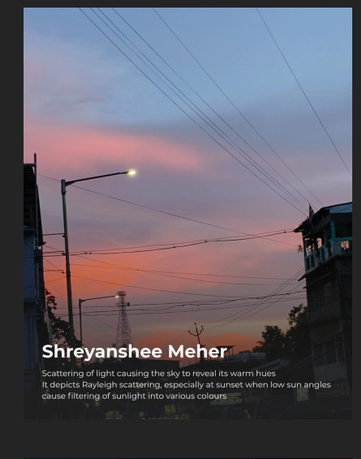
Navaneeth Krishna V

The photo is of a dammar bee doing a dance on a flower, this is done to signal the food source to its group . The pollen baskets can be seen on its hind limbs.



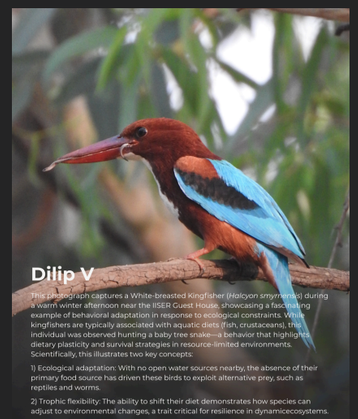
Amruthamshu A Koundinya

Against a serene sky, this lone bird in flight embodies the delicate balance of nature and physics. Its graceful movement reveals the principles of lift and thrust in aerodynamics, while its solitary journey hints at resilience and freedom. A testament to the marvel of evolution, the bird's intricate feather structure and adaptive design remind us of the interconnectedness of life and the importance of protecting such fleeting moments in nature.



Shreyanshee Meher

Scattering of light causing the sky to reveal its warm hues
It depicts Rayleigh scattering, especially at sunset when low sun angles cause filtering of sunlight into various colours

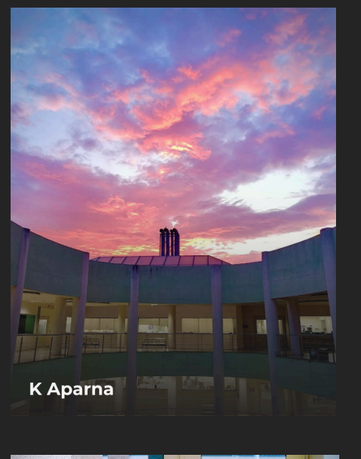


Dilip V

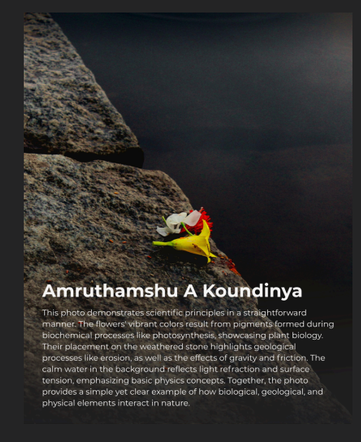
This photograph captures a White-breasted Kingfisher (*Halcyon smyrnensis*) during a warm winter afternoon near the IISER Guest House, showcasing a fascinating example of behavioral adaptation in response to ecological constraints. While kingfishers are typically associated with aquatic diets (fish, crustaceans), this individual was observed hunting a baby tree snake—a behavior that highlights dietary plasticity and survival strategies in resource-limited environments. Scientifically, this illustrates two key concepts:

1) Ecological adaptation: With no open water sources nearby, the absence of their primary food source has driven these birds to exploit alternative prey, such as reptiles and worms.

2) Trophic flexibility: The ability to shift their diet demonstrates how species can adjust to environmental changes, a trait critical for resilience in dynamicecosystems.

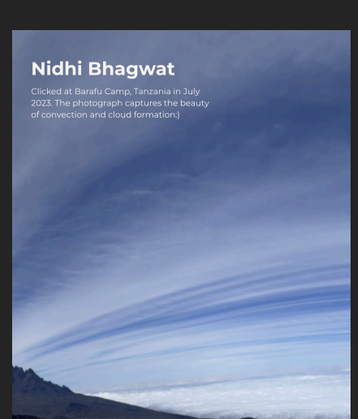


K Aparna



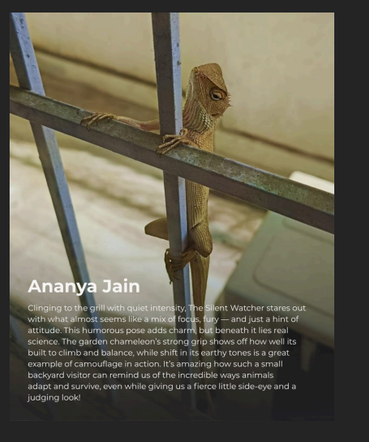
Amruthamshu A Koundinya

This photo demonstrates scientific principles in a straightforward manner. The flowers' vibrant colors result from pigments formed during biochemical processes like photosynthesis, showcasing plant biology. Their placement on the weathered stone highlights geological processes like erosion, as well as the effects of gravity and friction. The calm water in the background reflects light refraction and surface tension, emphasizing basic physics concepts. Together, the photo provides a simple yet clear example of how biological, geological, and physical elements interact in nature.



Nidhi Bhagwat

Clicked at Barafu Camp, Tanzania in July 2023. The photograph captures the beauty of convection and cloud formation)



Ananya Jain

Clinging to the grill with quiet intensity, The Silent Watcher stares out with what almost seems like a mix of focus, fury — and just a hint of attitude. This humorous pose adds charm, but beneath it lies real science. The garden chameleon's strong grip shows off how well its built to climb and balance, while shift in its earthy tones is a great example of camouflage in action. It's amazing how such a small backyard visitor can remind us of the incredible ways animals adapt and survive, even while giving us a fierce little side-eye and a judging look!

Shreyanshee Meher

Scattering of light at higher altitudes during sunrise as sunlight skims through the atmosphere horizontally leading to crisp bands of red light

Vansh Pathak

This photograph, taken with a Motorola Edge 50 Fusion, captures a Male Chrysilla volupe spider. Chrysilla volupe is a spider of the Salticidae family, commonly known as jumping spiders, is the largest family of spiders, comprising over 5,800 described species across more than 600 genera. The male Chrysilla volupe is renowned for its vivid coloration: a reddish-orange carapace adorned with two iridescent blue stripes, and legs that shimmer with golden and purple hues due to iridescent scales. This species was once thought to be extinct for over 150 years but was then rediscovered in 2018 at the Wayanad Wildlife Sanctuary in Kerala, India. As a member of the jumping spider family, Chrysilla volupe possesses exceptional vision, which it utilizes for hunting, navigation, and courtship. These spiders are agile predators, capable of leaping significant distances relative to their body size. Their vivid coloration is

Vansh Pathak

This is a photograph of a cat which can be seen in Main building at IISER Pune. The cat is named Bellatrix, and it's house cat. The name of the cat is a nod to the highly talented predator that has lived alongside humans for thousands of years, evolving from the African wildcat. Known for its sharp senses—especially night vision, acute hearing, and a powerful sense of smell—a cat perceives its environment with ease, using whiskers to detect subtle air movements and body cues to communicate mood and intention. While often perceived as independent, cats form strong territorial bonds and communicate with humans through meows, purrs, and body language. Their grooming habits, keen reflexes, and expressive eyes, like the green ones in the photo, reflect both evolutionary traits and selective breeding over centuries. The tabby coat pattern, as seen here, is one of the most ancient and naturally camouflaging fur types, showing the balance between domesticity and the cat's wild instincts.

Sanvi Gurpude

The photograph is of Panchvati Hills.
The hills are characterized by steeper slopes, contributing to the diverse terrain of the region.
Underlained by basaltic lava flows of the Upper Cretaceous age, with associated basic intrusive rocks. The hills support a variety of flora and fauna, offering a natural habitat for various species. The vegetation patterns are conducive to both tropical and exotic plant species.

Pratyush Kumar Biswal

An image of a water strider walking on water.
Importance and demonstration of surface tension of water

Vansh Pathak

This photograph captures raindrops clinging to a glass window which is clicked on Motorola Edge 50 Fusion that showcases several scientific phenomena.
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5) The soft and diffused light from the sky avoids harsh shadows which helps in achieving a moody image.

SCIENCE UNLIMITED

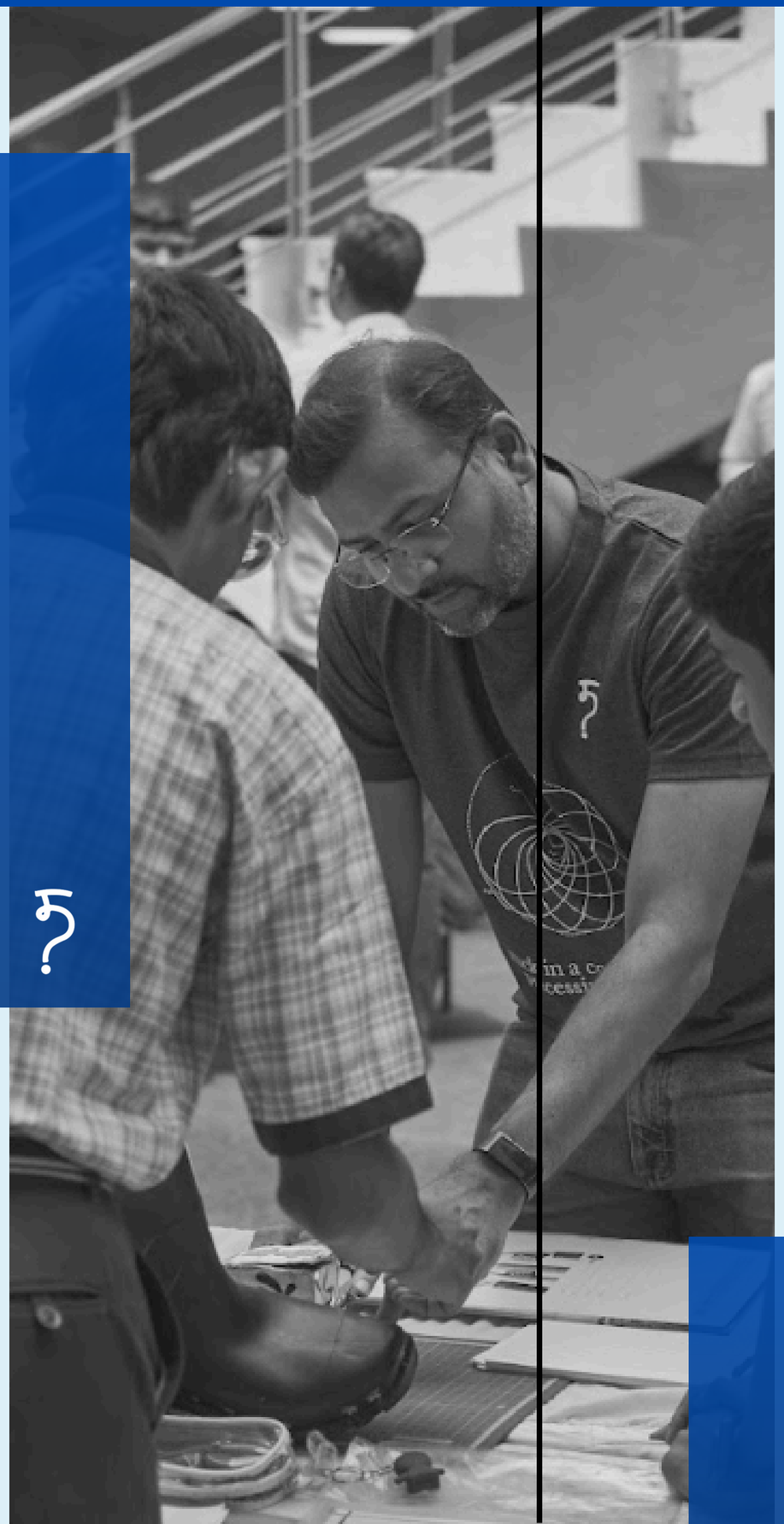
mimamsa

SCICON 2025

Where Curiosity Took Center Stage

~Saranya Ray

On a bright Sunday morning, the Lecture Hall Complex at IISER Pune buzzed with the kind of energy only science (and a lot of caffeine) can inspire. SciCon 2025, held on March 23, wasn't just an event. It was a celebration of curiosity, creativity, and collaboration. Across three floors, in lecture halls and corridors, the 4th edition of SciCon saw science come alive, and not just the textbook kind.



Mimamsa

Brainstorming >> Buzzwords

SciCon is one of the core pillars of Mimamsa, IISER Pune's flagship science competition that is as much about thinking as it is about science. Over the years, Mimamsa has become a national name, known for celebrating logic, deep understanding, and the kind of "why does this work?" questions that spark real learning.

Run entirely by students, it's more than a competition. It's a community of curious minds across India coming together, and it all starts here, in Pune.

Inter-School Science Exhibition Competition

Little Minds, Big Bang Ideas

Another highlight this year was the Inter-School Science Exhibition Competition (ISEC). School students from across Pune came in with their models, bursting with excitement and questions. Whether it was gravity, graphene, or glowing circuits, their enthusiasm was contagious.

Dr. **Shreyas Managave**, Dr. **Bhas Bapat**, and Dr. **Sourabh Dube** judged the entries, but more than judges, they were active participants in conversations, poking and prodding and marvelling right alongside the kids.

The top-performing teams were all girls, a heartening reminder of the growing presence and power of young women in science. This wasn't just about winning. It was about sharing joy in discovery.



Hallways of Hypotheses, Corridors of Curiosity

SciCon 2025 was a day when every hallway turned into a science lab, every room became a portal to a new idea, and every visitor, regardless of age, was drawn into the excitement. With over a dozen student clubs and many more individuals contributing, the event transformed the Lecture Hall Complex into a lively, layered science fair that went far beyond your typical expo.

This wasn't a "look-don't-touch" event. At SciCon, science was something you *did*.







Mathematics in Chemical Reactions

Anirban Hazra

We often think of mathematics in chemistry as a tool for balancing equations or calculating concentrations. But Dr. Hazra invited the audience to go deeper. In his talk, he peeled back the surface of everyday chemical reactions to reveal their mathematical heart: entropy and probability. He explained how the spontaneous direction of any chemical change is governed not by certainty but by statistical laws; how entropy, a measure of disorder, inevitably increases in isolated systems, and how probability theory underlies this fundamental truth of nature. Using real-life examples, accessible language, and his signature humour, Dr. Hazra made even abstract thermodynamic ideas feel intuitive. By the end, the audience was left with a new appreciation for how mathematics isn't just adjacent to chemistry; it drives it.



Jugglology

Steven Spallone

From the moment Dr. Spallone tossed his first juggling ball into the air, the room knew this wouldn't be an ordinary lecture. In Jugglology, he introduced the surprising mathematical structures hidden in the art of juggling. Behind every trick are precise numerical sequences, timing patterns, and spatial symmetries. With an engaging mix of performance and explanation, Dr. Spallone showed how serious jugglers use math to design entirely new patterns—and how anyone can begin to understand them with a few simple rules. Attendees not only watched juggling; they learned how to think like jugglers, decoding the rhythm of objects in motion. The result was a talk that was part math class, part circus act, and entirely captivating.

Clubs, Chaos, and Creativity

Each participating club transformed their space into a thematic exhibit that reflected their spirit and interests, offering something for everyone

Disha kickstarted the morning by orienting visiting school students and guiding them through the day with warmth and enthusiasm. Their SNP (Science Nurture Programme) session helped frame science as a lifelong journey, not just a school subject.

Cubing Club offered hands-on solving sessions, taught visitors how to tackle Rubik's Cubes from scratch, and demonstrated how group theory underpins the cube's permutations.

Pixels showed how physics and photography can create magic. Their "Light Drawing" setup lets participants create art using long exposure photography, capturing the physics of motion and light in a single frame.

The Science Club created a compact but powerful exhibition space. One corner explained the tech behind QR codes using interactive stations. Another dove into the microscopic world of quantum dots, showing their use in everything from TVs to medical imaging. In addition to the exhibits, the club hosted two crowd-favourite events. *Doodle Dash*, a science-themed Pictionary, turned chaotic sketches into moments of shared hilarity and learning. *Bad Ad Hoc Hypothesis* invited participants to cook up wild, scientifically incorrect explanations for everyday phenomena.

Chess and Maths Clubs joined forces to explore the deep links between strategy and logic. Attendees could learn about the symmetry in chess positions, fold paper into intricate origami designs while understanding the geometry behind them, and discover the hidden order in chaotic knots and Penrose tilings.

Satrangi offered a beautiful, reflective space that brought together art and identity. Face painting and henna tattoos weren't just decorative but each design told a story. Their posters encouraged dialogue on gender, sexuality, and diversity in science spaces.

Art Club brought science and creativity together in the most vibrant way possible. Visitors explored how different organisms perceive vision, learned about colour perception and colour blindness (with a fun colour test!), and even dabbled in the physics of beauty by creating Lissajous figures using sand. And as a chaotic cherry on top, everyone collaborated on a massive pixel art piece.....which turned out to be a glorious Rick-roll.

Literary Club hosted a fun-filled Spell Bee for school students, where kids took on the challenge of spelling tricky science words. The words got tougher with each round but so did the smiles. It was a cheerful mix of learning and laughter, where even the mistakes were met with applause.

iPlug brought tech to life with interactive demos that turned complex ideas into playful learning. An AI-powered Flappy Bird game showed how machines learn in real-time, with kids jumping in to try to beat the bot. A digital binary counter, introduced through a discussion on number systems, used lights to visually represent numbers in base-2. A compact ultrasonic sensor setup used lights and buzzers to show object proximity, sparking conversations on smart tech—from energy-efficient lighting to home automation.

Aakashganga brought the cosmos indoors. With guests from LIGO-India, students got a firsthand look at how laser interferometry detects gravitational waves from cosmic collisions. They also had stalls featuring a sunspot viewer for safely observing solar activity and a working horizontal sundial, blending modern astrophysics with ancient astronomy.

One of the individual stalls uniquely blended logic and art through John Conway's Game of Life, inviting visitors to explore this classic cellular automaton by experimenting with patterns that repeated, disappeared, or remained stable. It also featured Lenia, a continuous version of the Game of Life, where lifelike digital organisms emerged and evolved while another one focused on the acoustics behind musical instruments, using hands-on demos to reveal how vibrations, resonance, and material properties shape sound, leaving visitors with a newfound appreciation for the physics behind music.

Workshops like Play–Pause–Peace, beautifully facilitated by counsellor Deepali Awkale, reminded us that science doesn't always have to be fast and competitive. Sometimes, it's about pausing, sharing, and letting your mind and body be. Through singing games, open circles, and peaceful movement, participants got to experience science as something deeply personal and restorative.

Science: Live & Unscripted

SciCon 2025 wasn't just an event. It was a living, breathing snapshot of what science looks like when it's in the hands of students: free from the pressure of exams, infused with art, curiosity, and a lot of joy.

And looking ahead? Next year promises even more: bigger spaces, more schools, new experiments, and bolder ideas.

> *"SciCon 2025 wasn't perfect — it was better. It was alive, unfiltered, and powered by caffeine, cardboard, and curiosity. No grades, no rubrics, just vibes. And science. Was it chaotic? Yes. Did it work? Also yes. This is what happens when you let students take the reins and run with wonder."*
>
> — **Saranya Ray**, SciCon Coordinator



MATHS CLUB
IISER PUNE

~Saranya Ray

A PIECE OF PI

What happens when sharp minds, tricky puzzles, and an over-the-top love for math come together?

You get Pi Week 2025 at IISER Pune. A week filled with lectures, competitions, and activities that took us from ancient geometric mysteries to modern mathematical ideas. It was a celebration that only true math lovers could dream up.



We kicked things off on 8th March with a lecture by Dr. Anisa Chorwadwala. Her talk, "Area and Perimeter of Some Shapes, and the Story of Queen Dido", introduced us to classic geometric puzzles. For example, how rectangles with the same perimeter can still have different areas. She then connected it to the ancient legend of Queen Dido. It's one of the earliest known optimization problems in history. It turns out that math has always been hiding inside human stories.

The talk was held in NLH and aimed at visiting students from classes 7 and 8. They came in wide-eyed and curious, and honestly, quite sharp. After the lecture, and some very necessary Pi Day cake, everyone headed to the LHC foyer. There, a full-blown math fair was waiting. Students and clubs like the Science Club, Art Club, Cubing Club, Aakashganga, and iPlug had turned the space into a maze of puzzles and displays.

Some highlights included Penrose tiling setups you could interact with. There were games explaining group theory. One stall showed how to estimate π using Buffon's Needle experiment. And yes, they used actual needles. There was even a surprisingly fun stall on knot theory.





Later in the day, we got two back-to-back lectures on more abstract and serious topics. First up, Dr. Chandrasheel Bhagwat gave a talk called "***Primes and their Distribution: Order, Randomness and Bias***". He began with Dirichlet and Chebotarev's results. Then he explained the prime number theorem and how it relates to the Riemann Hypothesis. One of the most interesting parts was about Chebyshev's bias. He showed how prime numbers aren't distributed as evenly as we might expect. And how this weirdness connects to Galois groups and probability.

After that, Dr. Rama Mishra gave a talk called "***Mathematical Theory of Knots in Understanding Proteins***". She explained how knot theory, which is usually considered pure math, can be used in biology. In particular, in understanding how proteins fold. She made a solid case that elegant math can help explain the chaos inside living cells. The topic was deep, but her delivery kept even the first-years mostly engaged.

TREASURE HUNT

That night, the campus turned into a giant puzzle. The Pi Week Treasure Hunt took over, and it was total mayhem. Teams ran around chasing clues that got more cryptic as the night went on. People retraced steps, argued over riddles, and guessed wildly. At one point, a bicycle went missing near the amphitheatre. Some groups nearly broke down, while others found breakthroughs out of nowhere.

There was yelling. There was laughter. Some desperation. But through all the confusion, teams kept going. By the end, cheers and groans filled the air. It was chaotic, smart, frustrating, and brilliant. Everything Pi Week is meant to be.

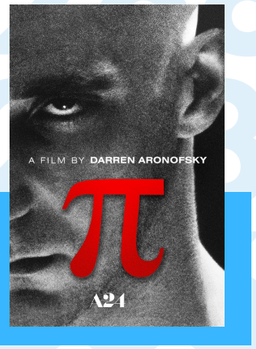
The next evening brought a strange but unforgettable event. It was called 'Crocs and Balls Against Turtles'. The name came out of a scheduling clash with Prutha over a turtle-hatching trip and just kind of stuck. The event was half puzzle, half throwing-things-around, and all fun. Nobody knew exactly what was going on. People laughed, got confused, and somehow ended up grinning by the end.

10 MARCH

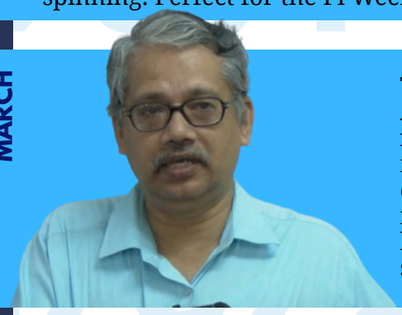
We hosted the Erdős Quiz with the Quiz Club. It was sharp, strange, and full of surprises. Some questions needed bold guesses and 'Erdős' was a valid answer (sometimes). Everyone left amused, a little puzzled, and happy.

12 MARCH

On 12th March, it was movie night. We screened Pi (1998), Darren Aronofsky's cult classic. The film follows a math genius obsessed with finding patterns that explain the universe. It was dark and intense. The kind of film that leaves your brain spinning. Perfect for the Pi Week vibe.



13 MARCH



The final day, 13th March, began with a talk by Dr. **Amartya Kumar Dutta** from ISI Kolkata. His talk, "**π in Indian Mathematics**", was all about how Indian mathematicians approached π over centuries. From early approximations in ancient texts to the amazing infinite series developed by the Kerala school. It was both historical and mathematical, and incredibly satisfying to listen to.

After that came something different. Surya and Avyay took the stage for a performance on math and music. They showed how numbers hide behind rhythm, melody, & harmony. It was unexpected, clever, and beautiful. To close things out, we had a skit called Life of Pi. It was written by Dr. Steven Spallone and directed by Sritama. The play was full of humour and insight. Laughter echoed across the room more than once. The applause at the end said it all.

Then came the prize distribution. Winners from all events were recognised and cheered. Finally, we wrapped up with a grand dinner. People shared stories, jokes, and moments from the week. There were no puzzles left to solve. Just good food and good company.

Pi Week 2025 was everything we wanted it to be. It was clever, messy, exciting, and unforgettable. Thanks to everyone who helped make it happen. Whether they solved something, asked a question, acted in the skit, or just showed up and smiled, everyone was a part of it.

See you next March for another round of irrational fun!



MS THESIS

“We are pleased to announce that, as with the previous years, we are back with another edition of the MS Talk Series by the Maths Club. This year, we have eight excellent students of our IISER family who have done their MS Thesis in mathematics in the year 2024-25. Each talk aims to unearth a new topic in mathematics and the interesting discussions that follow it. “

An excerpt from the Math Club email about their MS talk series. Below are the names of the people who gave the talks and a memorable moments captured in photo of the Math Club General Coordinators, and the Math Club faculty Coordinators with the students who gave the talks.

Naren S Narayanan
APRIL 07, 2025

Bhagya-lekshmy
APRIL 10, 2025

Prasanna N Bhat
APRIL 11, 2025

Aditya Marodia
APRIL 13, 2025

Naman Pratap
APRIL 14, 2025

Ameya Abhijit Tilgul
APRIL 15, 2025

Manjima Ghosh Hazra
APRIL 17, 2025

Yash Karampuri
APRIL 18, 2025

A year of Wonder, A Day of Discovery

Snippets from IISER Pune’s Social Outreach Club, ***Disha***’s recent visit to Science Park, a collaborative effort with the Science Activity Center's Kalpakghar at the Pimpri Chinchwad Science Park and Disha’s Science Nurture Program (SNP). Dedicated to sparking a love for science among underprivileged children, SNP holds engaging sessions for children in and around Pune every Sunday. This visit marked the final session of the year.











AAKASHGANGA
THE IISER PUNE ASTRO CLUB

AAKASHGANGA

KEY EVENTS

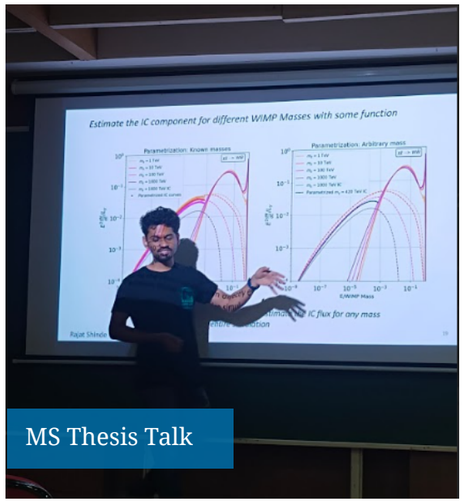
Aakashganga, in partnership with Gypsy Soul, organized an overnight stargazing trip on 24th January, 2025 at Panshet, and were accompanied by 140 people. One of the benefits from the trip was that the trip was guided by seasoned astronomers who helped them view many celestial objects with well-equipped telescopes. Moreover, astrophotography tips and tricks were shared along with a bonfire, food stalls, karaoke and much more



The Overnight Trip



Talk by LIGO India speakers



MS Thesis Talk

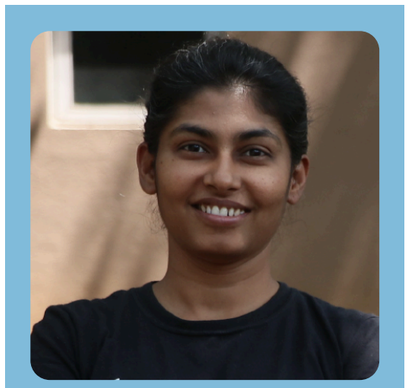
Aakashganga organised talks by LIGO India speakers, who are also faculty at IUCAA. They talked about their current work and the future of gravitational wave research.



Nuts and bolts of terrestrial gravitational wave detectors

Manasadevi P. T.

FEBRUARY 01, 2025



Gravitational lensing in the next generation surveys

Anupreeta More

FEBRUARY 02, 2025

MS THESIS

"We are pleased to announce the fifth edition of the MS Thesis Talk series by Aakashganga, where the senior most BS-MS batch on campus who have worked in Astro-related fields this year talk about their work and experience working in the field. Each talk unearths different possibilities ranging from astrobiology and astrophysics to cosmology and an interesting discussion."

06 APRIL Nishant Kulshreshtha

07 APRIL Kwanit Gangopadhyay

08 APRIL Gaurav Pundir

09 APRIL Rajat Shinde

10 APRIL Amoghavarsha A V

11 APRIL Subiksha S

12 APRIL Harshit Raj

13 APRIL Mayank Singh

PRUTHA

A TREE WALK AROUND THE IISER CAMPUS

~ Nidhi Bhagwat

It is hard to miss the lush green hues and vibrant colours when you step onto the IISER Pune campus. From the golden showers of the Bahava tree to the red-orange blossoms of the Sita Ashok, the campus is home to hundreds of endemic and rare species, making it a mini botanical wonder.

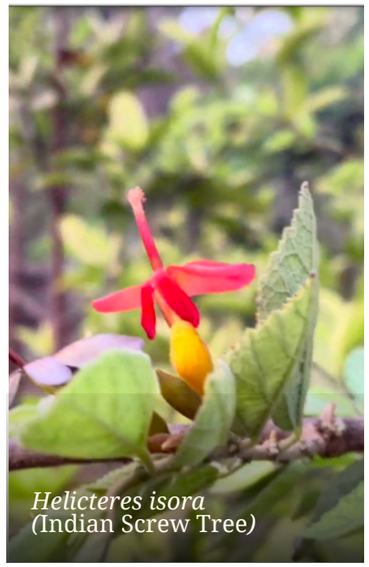
On April 5, 2022, **Prutha** organised a tree walk as a small initiative to connect the IISER community with the flora they pass by every day. The walk was led by Mr. Bhanudas Chavan, who shared fascinating ecological facts and stories along the way. His enthusiasm and deep knowledge about the trees kept everyone engaged and curious to learn more. It was surprising to discover just how much diversity exists within arm's reach!



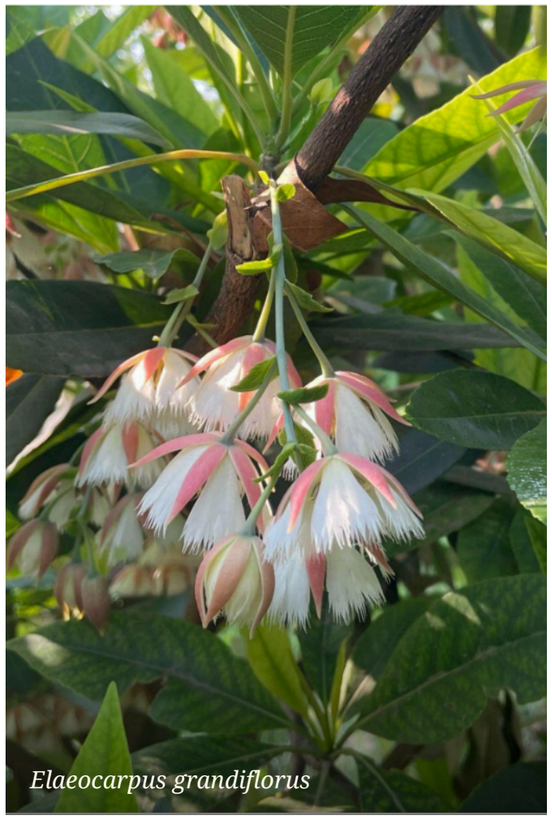








Helicteres isora (Indian Screw Tree)



Elaeocarpus grandiflorus





Cassia fistula (Bahava)



Saraca asoca (Sita Ashok)



Bixa orellana (Lipstick tree)

The walk saw a great turnout from students, faculty, and staff. Although only a small section of campus called the RET (Rare, Endemic, and Threatened species) area was covered, Prutha hopes to organise many more walks in the future to explore other parts of and around the campus.

GEOLOGICAL FIELD TRIP TO GHORADESHWAR

~Raj Bagwe

The Deccan Volcanic Province is one of the largest volcanic landscapes on Earth, formed approximately 66 million years ago, as the Indian plate passed over the Reunion hotspot. This landscape is marked by flood basalts resulting from giant eruptions that engulfed large swaths of land with basaltic lava flows. This also resulted in the creation of the Deccan Traps (trap- Swedish for stairs), called so because of the step-like appearance of the landscape due to lava flows stacked on top of one another. The Ghoradeshwar hill is an interesting site because of the presence of a naturally formed lava flow cave, a rare formation that freezes in time the rivers of lava that once flowed on the surface of the Deccan. Not only this, but the hill also boasts Buddhist caves carved into its western slope. Apart from being of cultural significance, these caves also provide a beautiful cross-section of the rocks, a geologist's wet dream. Initially, the trek was planned on Sunday, 9th February. But seeing the number of registrations we were getting and not wanting anyone to miss out, we decided to go twice, on the 8th and the 9th of February.





We boarded a bus from the front gate to the Shivajinagar railway station early in the morning, and got on a local train to Begdewadi. From there, it was a 15-minute walk to the base of the hill. The hill was a long and formidable trek for some inexperienced climbers. Fortunately, the mountain offered us frequent pauses, revealing intriguing geological features every 10–15 minutes, each demanding our attention and admiration.

Of the many interesting things we saw on the way, a layer of 'red bole' was one of the most prominent. This layer of red brittle rock contrasted sharply with the strong black basalts we saw above and below it.

These layers are formed when eruptions pause and a lot of time passes between two successive layers. This pause allows the top layer to be leached and chemically weathered by oxidation, making it brittle and red. This layer then gets preserved in time when the next lava flow comes on top of it. Being an easily erodible layer, the red bole acts as a buzz-saw that cuts through the mountains of the Deccan, creating that iconic step-like look. Further ahead, we came across a slab of rock with cracks spread out in a hexagonal pattern. The cracks were formed when the lava was cooling rapidly and thermally contracting. These thermal centres pull inward while cooling, and if evenly spaced out, cause the formation of hexagonal patterns in the rocks. A famous example of these is the Giant's Causeway in Ireland. Many of these cracks were filled with sheet-like veins of quartz and other minerals. I couldn't help but pick a piece of sheet vein of quartz to take home for myself.

Further up the hill, we came across these onion-like peeled rocks, formed by exfoliation. These rocks leave adorable concentric circular marks on the ground because of each layer getting plucked out (see photo). A little girl alongside us on the hike asked her dad if these were ancient dinosaur eggs. These are formed primarily due to the heating and cooling of rocks, which causes thermal expansion over the surface layer that comes loose and falls off. Going further up, we came across a layer of basalt with tons of tiny vesicles. These vesicles are ancient bubbles formed when the dissolved gases were trying to escape the cooling lava but got frozen in time as the lava solidified. We also noticed that some of these vesicles were filled with white minerals. These are called amygdaloidal basalts, where the vesicles are filled with other minerals. These are often found in bands near the top of the lava flow because most gas bubbles tend to accumulate up there, as they flow upwards. Meanwhile, at the bottom of the lava flow layer, we find 'pipe-vesicles', which are cylinders in the rock about 2-3 cm long. Pipe vesicles (see photo) are formed by denser impurities in the lava, which flow down under gravity, carving out these cylinders, which then get filled with other minerals. These are often tilted, instead of being vertical. This is because the lava, while cooling, is often in motion, making the tilted pipe vesicles.

Soon we reached the top of the mountain. The view was breathtaking. From the top, we could see the whole landscape of the area clearly. This sparked an interesting discussion about the evolution of the Western Ghats escarpment and the geomorphology of the Deccan Traps. After a few quick refreshments on the hilltop of kokum juice and lemonade, we descended the southern slope to the lava cave. A natural lava cave, also known as a pyroduct, is basically an ancient river of lava that has been drained of its fluid. The river of lava starts cooling from the top and the sides first, which solidifies and forms a roof for the lava river. Once the eruption stops, all the lava in the river flows downhill, and the hollow tube with the roof and walls is left behind. This becomes the product.

The roof of the pyroduct was made of a glassy red rock, which is formed when lava cools down very fast. The lava tube extends 20 metres in either direction, and one can easily crawl inside as long as they aren't claustrophobic. All of us took turns going in, so as to ensure that there is no lack of oxygen. Inside, we found bones of a small mammal that probably used the caves for shelter at some point. A hiker family that saw us take a curious path down to the cave also followed us, and we gamily gave them a geology lesson as well.

After spending a while at the pyroduct, we continued to the Buddhist Ghorwadi caves. We were offered some breathtaking views of the MCA cricket stadium on the way. Near the caves, few keen 1st years spotted some drongos, birds characterised by their V-shaped tails.

This ended our field trip, and we began our descent back to the train station to catch the train back home. On Saturday, there were around 12 people, and all of us got on the train on time. But on Sunday, when there were about 40 people, the train got cancelled and we had to take the bus back to Pune. It was a chaotic experience, but all of us got back safe and sound. It was a long and tiring day, worth every second. I will forever cherish the memories. If you missed the trek, don't worry, this spot is going to be on the Prutha calendar for at least a few years now. See you there!

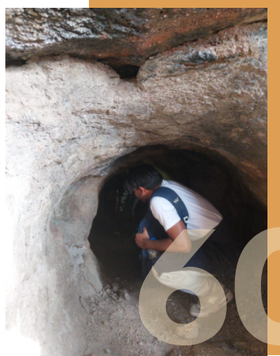
Photo credits: Rashi Sangoi & Raj Bagwe













A BIT ABOUT ABIT SCIENCE

~Suhani Bhattacharyya

'Abit Science' is a science communication platform created by *Prarabdh Shivhare*, where, as of now, students and faculty in academia talk about various research opportunities they have had, as well as provide tips for other students on how to navigate the academic space. With a current following of about 8.5K on the 'Abit Science' Instagram account, Prarabdh's journey of building 'Abit Science' is a unique one.

Abit about Prarabdh

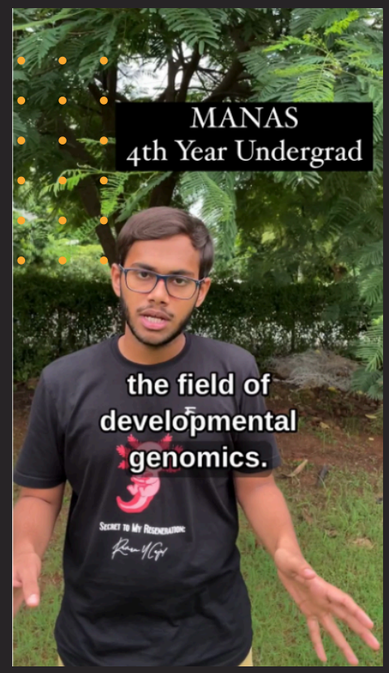
Prarabdh was a BS-MS student at IISER Pune. His work is in the field of biophysics and machine learning. After a lot of trial and error with various labs, as well as through learning about different fields from the courses at IISER Pune, Prarabdh ended up working in a field which is at the intersection of all five departments at IISER Pune.

"I feel like I actively use my knowledge from courses across the Math, Data Science, Biology, Physics, and Chemistry departments in my research. This was one of the motivations behind taking science journalism a little more seriously and wanting to ask people questions about what they do. I was genuinely interested in everything."

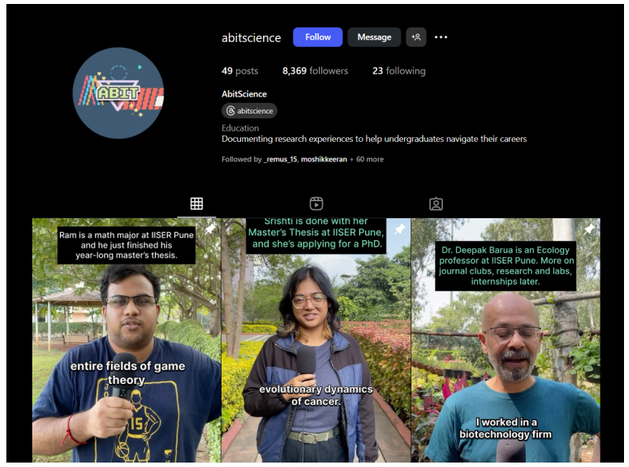
The 'Abit Science' YouTube Channel

On March 27, 2023, the first YouTube video from the Abit Science channel, titled 'Abit About Global Ecology, Microbes, Climate Change and Conservation', was posted. Especially grateful to the Science Media Center (SMC) at IISER Pune for advice on video and audio editing, the first video was a result of many drafts and retakes.





The 'Abit Science' Instagram Account



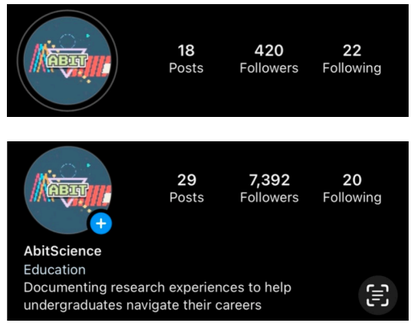
The interviews posted on the Instagram account were a switch from the kind of videos posted on the YouTube channel. When asked about why he switched from YouTube videos about random scientific topics to reels on Instagram with interviews, he explained a few reasons. First, from a technical standpoint, Instagram reels are easier to record and upload. Rather than spending three months on one video, through reels, he could spend one or two hours on them while reaching a much broader audience. This also satisfied his aim of trying to build a bigger platform for 'Abit Science'.

"When I came to IISER, I had never really come to IISER, in the sense that our first year was in the pandemic." The pandemic created a lack of flow of knowledge and tips, which many incoming first years get to know by interacting with their seniors on campus, whether through accidental run-ins at the mess or during club activities.

"I thought if you are not from an academic background or if you are coming to IISER and you don't make the right friends with seniors and stuff, it's probably a bit hard to navigate the whole space. I thought if I could disseminate that information and provide that to a lot of people who are not even from IISER…". Firsthand accounts about how to apply for internships and how they work in both domestic and international spaces, through his account, could also reach those non-IISERites who may not be able to acquire this information at their institutes. On top of this, of course, it benefitted him to learn more about the work his peers were doing and the available opportunities for him at that stage in his career. Another reason was to try and create a repository for students just coming in to IISER, about how they can work, apply for internships, find various oppor-tunities, and build connections.

The first interview he conducted was of a BS-MS student, Manas Raikar, talking about the research his lab does at the Stowers Institute of Medical Research, how he was able to get into this lab, and how many cold emails he had to send before he was accepted through the Stowers Summer Program.

The interviews were not limited to students. The first faculty member he interviewed was Dr. Deepak Barua from the Biology Department of IISER Pune, with whom he was already familiar. After an hour of brainstorming what his interview would be about, Dr. Barua went on to stand in front of an array of plants, really driving home his role as a Plant Ecology researcher, and provided us with a look into his career as well as tips from the point of view of someone well established in the field about how undergraduates can develop their research skills.



The Expansion to Other Institutes

After about 20 or so interviews at IISER Pune, it was time to expand the repertoire of interviews. Prarabdh used his connections from club activities as well as cold emailed faculty members, and was able to obtain a set of very interesting interviews of people at different stages in their careers from all over India.

The first stop was IISER Berhampur. One of his contacts through club activities, Gayathri, was able to guide him in finding accommodations in the guest house and contacting the right people to interview for 'Abit Science'.

The next stop was NISER Bhubaneswar. He missed the first train that he had from Berhampur to Bhubaneswar because the people at IISER Berhampur were very nice and generously made themselves available for interviews with Prarabdh.
The Train to Bhubaneswar

Unlike the guest house accommodations at IISER Berhampur, at NISER, he had to make do with a hotel just outside the campus. Without a 'man on the inside', it was slightly more gruelling to get people to agree to interviews. His attempts included several emails to many of the faculty at NISER (clearly a success story with Dr. Anamitra Mukherjee and Dr. Tirumala Kumar Chowdary as some of the interviewees, one can see on the Instagram page for 'Abit Science'). A more demure response from the following stop, IISER Kolkata, was simply the fault of bad timing, with most of the possible interviewees busy with exams, resulting in a quiet campus. Yet, even under such seemingly discouraging circumstances, Prarabdh (once again living in a hotel outside of campus) was able to get quite a few students at IISER Kolkata to give interviews. A much more enthusiastic response was found at the Inter-IISER Cultural Meet (IICM), 2023. With their exams all done, students from all the IISERs, NISER, and IISc flocked to IISER Mohali to compete against each other, a perfect setting for Prarabdh to find his next targets.

Although his travel within India is no doubt remarkable, interviews with a PhD student from the University of Oxford in England, a research fellow visiting IISER Pune from the Konkoly Observatory in Hungary, and a post-doc working at the European Bioinformatics Institute in Cambridge (an interview which provided an account about research in Brazil, recorded despite a busy time while completing his thesis in Barcelona), highlight how effectively Prarabdh was able to use the situations he was presented with to grow 'Abit Science'.

The SMC fellowship

The Science Media Center at IISER Pune, collaborating with the Science Journalist Association of India, Nature India, the Association of British Science Writers, and the University of the West of England, Bristol, under the British Council Going Global Partnership project 2022-23, announced a SMC Student Fellowship where 4 students from IISER Pune would be selected, who could intern and work on a variety of areas of science communication including illustrating, writing, producing podcasts and much more. Prarabdh was among the few selected for this incredible opportunity. Mentored by Virat Markandeya (Vice President-SJAI), and Dr. Shalini Sharma (SMC Faculty Head), whom he had nothing but gratitude towards, Prarabdh and his project partner for the Student Scicomm Fellowship produced a video about exploring Zebrafish research in India, initially planned to be part of a 'vodcast' which would include some high quality illustrations of Zebrafish. Gaining experience from this in editing videos and learning more about science communication, he started posting interviews about the work done during internships by his fellow undergraduates at IISER Pune.





The Pause

In January 2024, he attended a science journalism workshop at NCBS, Bengaluru, hosted by Anil Ananthaswamy, "...which was an amazing learning experience around seasoned and enthusiastic science journalists," and where he made some other useful connections for 'Abit Science'.

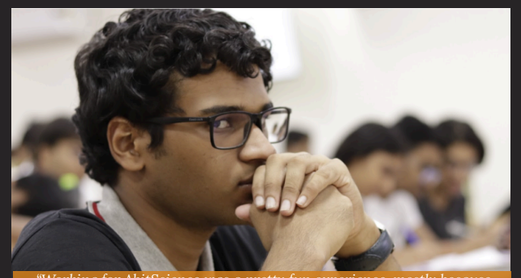
There also came a pause in uploading reels for 'Abit Science' due to a semester project, along with a load of emailing for his MS thesis work, and then actually completing the thesis. This, of course, led us to discuss his thoughts on recruiting others to help him grow and maintain 'Abit Science'.

Others...?

From everyday life on a college campus, we all know that we can be flaky about completing work that we either do not get graded for or that we do not get paid for (sometimes even that does not seem to matter as much as appeasing an annoying green owl teaching us languages). This is one reason Prarabdh seems hesitant to recruit people to scale 'Abit Science'. Although this has not stopped him from doing so successfully before. He was able to recruit two juniors at IISER Pune, Govind and Lochana, to work for 'Abit Science' when he had planned to shift the style of his interviews. He felt that asking one person many questions was becoming too repetitive. Instead, an interesting approach would be to ask the same question to multiple people and compare their answers, an initiative propagated through a delightful poster pasted on the dining hall window at IISER Pune.

The 'Abit Science' website features two others who are helping him manage 'Abit Science' - Mishika (the Manager), who joined him to help with 'Abit Science' in 2024, and also introduced him to Rohit (the Video Editor).

According to Prarabdh, 'Abit Science' is something that has the potential to benefit incoming first years. Not only do they get to interact and learn more from their seniors about undergraduate research, but once an inter-IISER community through 'Abit Science' can be established, this could be a great opportunity for first years to build connections with peers across India.



"Working for AbitScience was a pretty fun experience, mostly because I got to see the variety of research areas IISER undergrads work in. Seeing a lot of them getting very excited to talk about their niche was maybe the best part."

~ Govind R. Nair
govind.rnair@students.iiserpune.ac.in



"Jumping on board with Abit Science was one of the best things I did. It's this platform a senior of mine started, and it's all about getting a raw, unfiltered look into the academic journeys of researchers. My friend Govind and I got to interview a bunch of smart people about their academic journeys and the insights they've picked up along the way.
We were in charge of filming these interviews, which gave us a great excuse to meet a ton of seniors and learn about their work. I also had a great time designing the posts for the Abit Science social media feeds. It was a really nice creative outlet for me.
More than just the work, it was an incredible way to make friends and connect with students across different batches. The entire experience was a perfect blend of fun, learning, and networking."

~ Lochana T S
t.slochana@students.iiserpune.ac.in

The Future Plans

Future plans for Prarabdh involve working on outreach activities for the NCBS Archives, a 'public collecting center for the history of science in contemporary India', with Venkat Srinivasan, who runs the NCBS archives right now. Scaling 'Abit Science' is also a prospect, although it would require people to put in more time to increase the magnitude of work that can be done. Another possible plan is to make documentaries about labs and their work, which would not only benefit the lab but also provide them with the chance to get to know more about the lab. Making the aforementioned inter-IISER community through 'Abit Science' so that those involved can become a part of this community and have incentives to work for Abit Science is also a future possibility to look forward to for IISER students. "Hard Core Journalism" about science in India is another prospect the future may hold. This would include surveys collecting data about the issues scientists in India face, whether they are undergraduates, PhDs, or established researchers, and analysing this data.

A patchwork of motivation, ideas, and opportunities which he was able to utilise efficiently for his platform, Prarabdh Shivhare's journey building 'Abit Science' is truly impressive, and I sincerely hope he continues in his quest to make science more accessible, whether through Instagram reels or YouTube videos.

To contact him for more information or questions regarding 'Abit Science' or how to get involved in working with him on this platform, feel free to write to the email address: prarabdh.shivhare@students.iiserpune.ac.in.

HELICASE *Fall Edition, 2025*

In the Lab & Beyond

Stories of Scientific Pursuit

TRIPLY NEGATIVE, DEEPLY POSITIVE

Mapping Tumours with MADHURA KULKARNI



Dr. Madhura Kulkarni is the principal investigator at the Tumor Microenvironment Lab, IISER Pune. Dr. Kulkarni works in collaboration with clinicians from Prashanti Cancer Care Mission at the Centre for Translational Cancer Research, a first-of-its-kind centre in India. She tells us there are two angles to research: the clinical aspects - how drugs and treatments help patients respond, and the molecular pathology angle - the mechanisms of tumor progression and biology.

Dr. Kulkarni studies the host immune response to tumors in the context of therapy. She is interested in the role of tumor-infiltrating lymphocytes (TILs) in the stromal bed of breast tumors and their correlation with prognosis - the likely course of the cancer. While a vast majority (85% globally) of breast cancer variants have targeted therapies, Triple Negative Breast Cancers (TNBCs) do not express diagnostic markers like ER, PR, and HER2, which complicates their prognosis. Subtle differences across populations are significant, and the Indian population is ethnically different from Western cohorts, which are historically over-represented in medical studies. The incidence of TNBCs in the Indian population is much higher than in Western cohorts, at 35% [2].

Starting her career in research in Pune, she first became interested in transcription factor regulation during her MSc. in Botany at Pune University. She then went on to explore the role of YAP, a transcription factor that regulates collagen deposition, stromal composition, and ultimately immunocyte infiltration in tumors. With a PhD in developmental biology and postdoctoral stints at the Harvard Medical School, Dr. Kulkarni entered the translational domain in 2013 and has spent more than a decade in the field.

She learnt about multiplex imaging and spatial transcriptomics at conferences of the European Association of Cancer Research, and the facets of her research. Dr. Kulkarni's research group is one of the few in the world, and the first in India, to have the entire pipeline for spatial transcriptomics. Leveraging a large Biobank with upwards of 2000 patients, long-term follow-up data, and crucial clinical information, the lab generates important research on Indian cohorts. The data is challenging to analyse, with images frequently gigabytes in size, and requiring niche tools that cost lakhs to license.

The ability to ask and answer questions that directly impact patients is something that is amazing about this kind of research. Explaining the rationale behind translational research and informed consent is one of the most important aspects. However, it takes decades for research to advance to the level of benefiting patients. "It's a truly humbling experience to interact with the patients," she says, and encourages one to visit a cancer centre like ACTREC (now the TATA Memorial Cancer Center) at least once. Her group proposed a clinical trial based on androgen receptors in TNBC response. If successful, prostate cancer drugs could be repurposed to treat some TNBC variants.

In the coming years, the research group aims to study the combined effect of treatment response, considering the interactions between B-cells, T-cells, drugs, and tumor cells. They also want to study the role of other transcription factors like YAP, fibroblasts, and collagen in TNBCs. The ultimate goal in the long run is to develop vaccines against such tumors.

Another area of focus for the lab is the stromal characterization of tumors and tumor beds. The lab is already developing algorithms that use ML to predict the deposition of collagen in the stroma. This can then be used to predict the aggressiveness of tumors and set personalized screening schedules for patients, in what is called 'Digital Pathology.'

Telling us a bit about her life outside work, Dr. Kulkarni mentions that she is an avid hiker, and loves going on walks to Tekdis and Gads around Maharashtra. She also enjoys spending time with friends and loves a good movie. "There are none nowadays," she quips. Originally from Mumbai, the absence of the fast-paced lifestyle took her some getting used to, but she now enjoys the work-life balance in Pune. "IISER has a beautiful set-up that allows me to function independently as a researcher," she adds. "I am blessed to have very intelligent students who do not need to be pushed. Motivation has never been a problem here, which is even more important than facilities," she says.



Lab meetings usually involve engaging in discussions on a multitude of topics. They go out on trips to waterfalls and hikes, and play Secret Santa every December. Lab treats are also a frequent occurrence.

Speaking about the kinds of projects available, Dr. Kulkarni mentions that she is open to ideas as long as they make use of the rich resources available and are somewhat aligned with the lab. There are a host of topics to work on, from image analysis and developing an AI/ML digital pathology interface, to developing pipelines and integrating the above. There are also projects at the bench, like exploring immune cell types and crosstalk between pathways, studies with cell lines, and even studies with mice. While two-thirds of the research is in molecular pathology, the rest is with cell lines, including patient-derived cell lines.

Dr. Kulkarni also teaches a cancer therapeutics course at NCCS, Pune, and is open to teaching a course at IISER Pune shortly as well.

Reach out to her for projects and questions at:
madhura.kulkarni@prashanticancercare.org

~ S V Ananthakrishna

HELICASE *Fall Edition, 2025*

THE UNSATURATED PROFESSOR

Catalyzing Ideas with

BUDDHADEB CHATTOPADHYAY



An enthusiastic researcher, Dr. Buddhadeb Chattopadhyay had been inspired to start his own research group since a very young age. He did his Bachelor of Science from Burdwan University and Master's from Bishyobharati in Shantiniketan. As an undergraduate, he was initially admitted into the Mathematics Department as a BSc. Honours student. It was his teacher who told him that although he was brilliant at mathematics, to develop things as he wanted, he should switch to Chemistry. After spending 11 months in the Math Department, he stubbornly decided to request the head of the Chemistry Department to be able to switch to Chemistry and succeeded without ever having a career break. Passing the SLATE exam, he started his PhD at the University of Kalyani under Dr. K.C. Majumadar, one of the biggest organic chemists in our country. In 2009 he moved to the University of Illinois for his post-doctoral position where he learned how to break C-H bonds and make new molecules. After two years he moved to Michigan State University where he proceeded to spend about 4 years and switched his field to organometallic chemistry. Following this, he returned to India and his first position as an independent researcher was at the Centre of Biomedical Research, Lucknow. In 2025 January, he joined the Department of Chemistry, IISER Pune, as an Associate Professor. As a researcher, he believes that blending fields always intensifies one's knowledge. To invent new methods and catalysts, knowing about other fields such as organometallics allows for innovative methods and solutions to come forward.

Previous research in the development of new organic molecules used methods such as the cross-coupling reaction where functional groups such as a halogen atom needs to be added to the group to be able to break the C-H bond. Instead of this, directly being able to break the C-H bond is a cost-effective, resource-efficient way to develop new organic molecules to produce substances for use in biomedical and agrochemical fields. For this, a directing group needs to be attached to the substrate, then one can perform synthetic transformation and remove the directing group (called substrate engineering or design process).

This involved too many synthetic development steps and still uses up too many resources. That is when Dr. Chattopadhyay started thinking, instead of using this conventional route, why not develop a catalyst for this process so that the substrate can be used as it is. For his catalyst he mainly uses transition metals with a ligand. This process makes his method atom-economic as compared to other processes used for C-H bond breaking. His research groups also looks at borylation (how to put boron atoms in molecules). His group has developed many ligands which have also been commercialised under the name Chattopadhyay PYT ligand, available in the Sigma-Aldrich catalogue. Along with this, development of N-heterocyclic molecules is being done by his group. Methods to develop N-heterocyclic compounds normally use precious transition metals which are costly, toxic and not resource-efficient. His idea is to make non-toxic catalysts for N-heterocyclic compounds so that metal is incorporated into the cavity of porphyrin ring for catalysis to form N-heterocyclic compounds. His group is interested in nitrene and carbene chemistry, so that precursors would have nitrene groups and release N_2, which is a relatively non-non-toxic gas as compared to CO_2. The nitrene would couple with different coupling groups for annulation and activate sp^2 and sp^3 C-H bonds. These ligands earlier were reported to be very substrate specific. He wanted to develop ligands which could be used for different classes of substrates including aromatic, heteroaromatic, aliphatic and other compounds.

"Nothing is impossible, give your best and one day you can achieve it".

This message to his students worked wonders such that although it took 4 years, he developed generalised catalysts (two different classes - Ist and IInd generation). This commercialised product was highlighted in the Journal of the American Chemical Society and Science magazine. Right now they have made catalysts which can selectively target any C-H bond using the same catalyst. This has been patented and is being considered for publication.

To a student who enters his research group, first and foremost his message is to be honest and passionate about your research. Anyone, whether a PhD or an undergraduate, who is serious, devoted, motivated and passionate about their research and willing to build their knowledge base in the subject are welcome to join his lab. Those who join his lab will find themselves working with many air-sensitive materials which need to be kept in an airtight environment called a "glove-box". This box is always under the control of an inert gas atmosphere which is very tightly regulated, and where all the initial mixing of reactants happens. Fridge pump thaw, for reactions which cannot be set up in the glove box, is done using the 'sleighing technique' which is another air-free environment. Gas-chromatography mass spectrometry, HPLC, rotary-evaporator and nuclear magnetic resonance are also techniques one can learn upon joining his lab to calculate the exact ratio of carbon-hydrogen bonds broken and identify the products formed.

Like a true bengali he enjoys literature, such as the writings of Sarat Chandra Chattopadhyay, detective novels, Ami Subhash Bolchi by Shailesh Dey, as well as sports, such as cricket. Describing himself, he says he is a very 'unsaturated' person (for those who get it). He wants to develop better, more powerful catalytic systems which will be used all over the world which can cut the synthesis steps down and develop greener and economic ways to break C-H bonds and perform borylation. At IISER Pune, along with his research he has been taking classes for the course Organometallic and Transition Metal Chemistry. In the August 2025 semester he will take the Advance-level practical course for all the BS-MS students. Along with this, he is also an editor for the Royal Society of Chemistry Journal. From our conversation it was clear that he cared deeply about his research and those who are in his research group. What he hopes students take away is to be passionate about whatever they are doing and to remember,

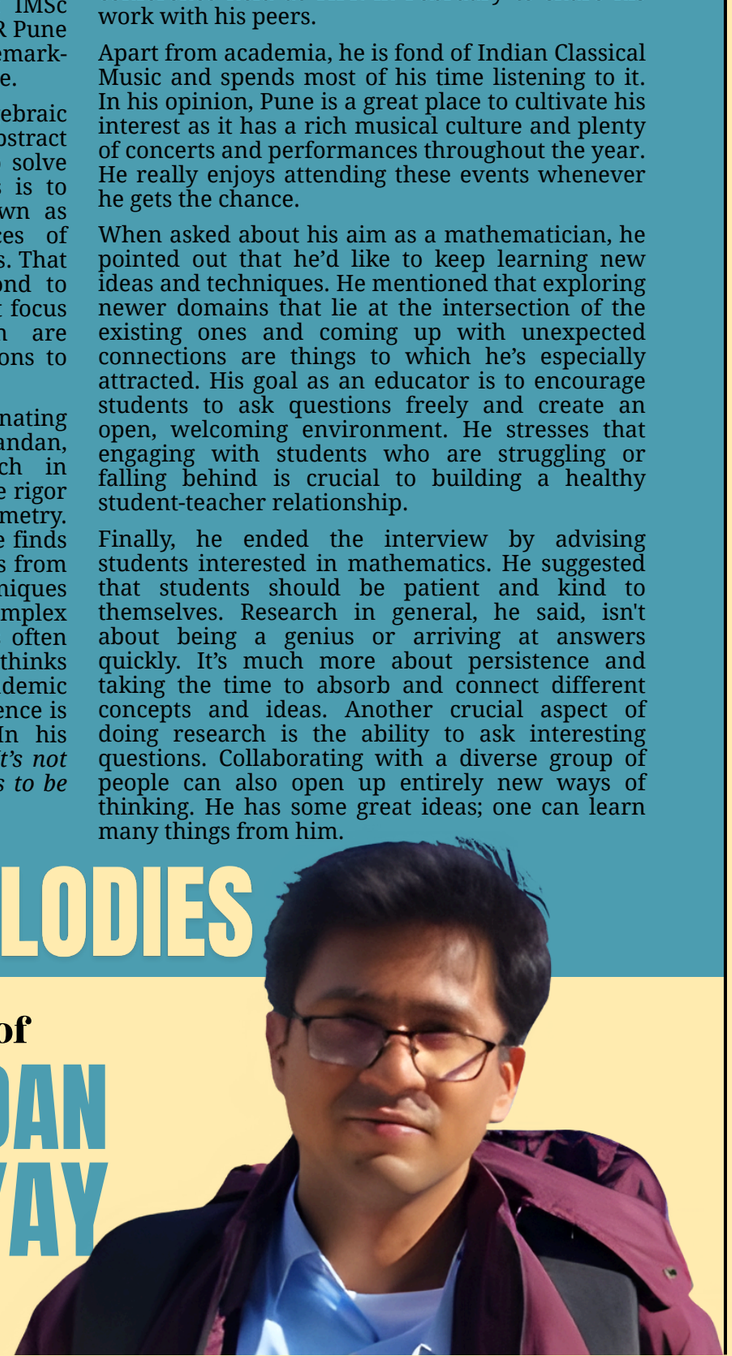
"Nothing is impossible, give your best and one day you can achieve it".

~ Suhani Bhattacharyya

MODULI & MELODIES

Tracing the dual passions of CHANDRANANDAN GANGOPADHYAY

– Anhad Jha



Dr. Chandranandan Gangopadhyay is an INSPIRE Faculty Fellow at IISER Pune. He joined IISER Pune in September 2022. He is originally from Kolkata, where he also did his schooling. He then earned a Bachelor's in Mathematics from the esteemed Indian Statistical Institute (ISI), Bangalore. Ascending above the academic ladder, he continued his educational explorations as a Masters student at CMI, where the brightest minds of mathematics in the nation dwell. Going forward to get his Doctor-ate Degree in Algebraic Geometry at TIFR under the supervision of Prof. Indranil Biswas, he held Post-Doctoral positions at IMSc Chennai, and IIT Bombay before joining IISER Pune as an INSPIRE Faculty Fellow. He has had a remarkable academic career and research experience.

His research interests lie in the field of algebraic geometry. This field mainly deals with abstract algebraic frameworks and employs them to solve geometrical problems. His particular focus is to study the geometry of special spaces known as moduli spaces. Moduli spaces are spaces of solutions of geometric classification problems. That is, the points of a moduli space correspond to solutions of geometric problems. His current focus lies in exploring toric varieties, which are geometric objects with interesting connections to convex geometry.

His interest in mathematics started germinating from the very start. According to Chandranandan, what convinced him to pursue research in Algebraic Geometry was how it integrates the rigor of algebra with the intuitive nature of geometry. Another aspect of algebraic geometry that he finds appealing is its ability to bring together ideas from various other areas of mathematics. Techniques and ideas from fields like number theory, complex geometry, topology, and even combinatorics often come together in quite elegant ways. He thinks there is a clear difference between other academic disciplines and mathematics, and that difference is the emphasis on rigor in mathematics. In his words, *"Nothing is accepted without proof. It's not enough for an idea to sound plausible—it has to be airtight."*

He describes his experience at IISER Pune as very positive regarding research and teaching. He highlights that he got to teach and engage with a group of extremely sincere and diligent students. One of the things he particularly appreciates about IISER Pune is the academic freedom it offers, which he finds to be truly refreshing.

He has gathered various accolades over his academic career and has published three papers in the past year. Three additional preprints of his are currently under review. He was also invited to a conference held at TIFR in February to share his work with his peers.

Apart from academia, he is fond of Indian Classical Music and spends most of his time listening to it. In his opinion, Pune is a great place to cultivate his interest as it has a rich musical culture and plenty of concerts and performances throughout the year. He really enjoys attending these events whenever he gets the chance.

When asked about his aim as a mathematician, he pointed out that he'd like to keep learning new ideas and techniques. He mentioned that exploring newer domains that lie at the intersection of the existing ones and coming up with unexpected connections are things to which he's especially attracted. His goal as an educator is to encourage students to ask questions freely and create an open, welcoming environment. He stresses that engaging with students who are struggling or falling behind is crucial to building a healthy student-teacher relationship.

Finally, he ended the interview by advising students interested in mathematics. He suggested that students should be patient and kind to themselves. Research in general, he said, isn't about being a genius or arriving at answers quickly. It's much more about persistence and taking the time to absorb and connect different concepts and ideas. Another crucial aspect of doing research is the ability to ask interesting questions. Collaborating with a diverse group of people can also open up entirely new ways of thinking. He has some great ideas; one can learn many things from him.

THE ALCHEMIST OF PLASMA

Crafting Chaos in the Lab with SURABHI JAISWAL

~Aaditi Mante



Is plasma just lightning or neon signs? Or could it be the key to unraveling mysteries of space and medicine? More often than not, we first recall the definition of plasma, i.e., a fourth state of matter or sometimes, an ionized gas. Here, we will not be discussing its definitions as such, but get to know one of our professors who has been working on the physics behind it. By this, we mean looking deeper into the subject of plasma physics to uncover some real and intriguing facts besides Dr. Surabhi Jaiswal, who has been an expert in the field and a researcher in this domain (especially, in low-temperature plasma) for the past ten years.

One may wonder what it takes to get opportunities to work with people who inspire you and to finally find your true research interest! One such answer lies in the journey of Dr. Surabhi, who turned from being an early enthusiast in science and designing into a deeply motivated scientific researcher. She pursued her master's at Allahabad University in core sciences and moved to NCRA-TIFR (National Center for Radio Astrophysics, Pune), where her belief in choosing science as a career got strengthened after working and interacting with other scientists.

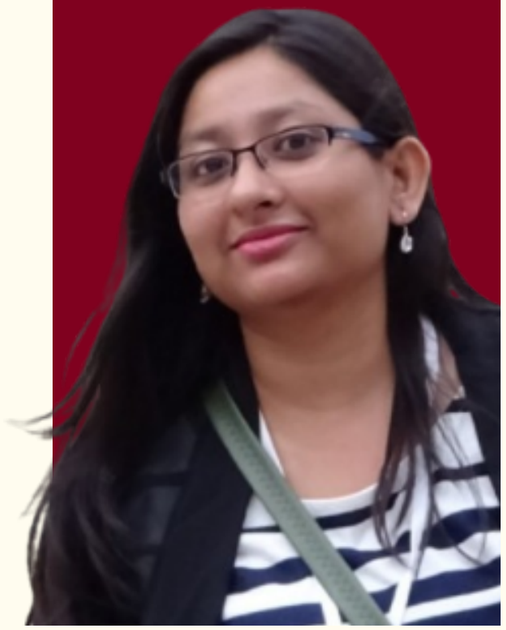
She gradually developed her research interest in plasma physics, where one explores the behavior of charged particles (like electrons) in electric and magnetic fields and relates it to astrophysical, industrial, or biomedical environments. As a recipient of prestigious fellowships, she completed her PhD on nonlinear waves and structure excitation in flowing dusty plasma at the Institute for Plasma Research. She then began her postdoctoral research at the German Aerospace Center (DLR), preceding her work at Auburn University, leading to ongoing collaborations. One of her current projects with DLR involves studying dusty plasma under microgravity conditions aboard the International Space Station (ISS).

Dr. Surabhi is currently working on the behavior of charged particles in dusty plasma across varying environments. Her lab is equipped with highly specialized cameras for studying particle-plasma interactions and employs techniques like spectroscopy and optical imaging. Plasma Physics, as she insightfully describes, is an interdisciplinary field with applications spanning interplanetary studies, plasma chemistry, plasma medicine, and materials science (including semiconductors, etc.).

Her interests include playing table tennis, volleyball, and listening to classical music (especially while immersed in scientific thought). Along with that, she enjoys novels like The Alchemist and biographies such as that of Srinivasa Ramanujan (including Vinamra Vidrohi).

She teaches fundamental and advanced physics labs at IISER Pune. Moreover, having previously taught plasma physics to undergraduates, she hopes to offer a full-fledged course on it here. She believes learning is a two-way journey, where students must engage deeply with the principles behind experiments. Therefore, she's been actively bridging learning gaps while also encouraging students to explore widely, beyond preconceived paths.

If you're a science enthusiast intrigued by the challenges of connecting theory and experimentation in plasma physics — from everyday applications to mysteries of the plasma universe — you're always welcome in her lab. Ask questions, have a discussion on the topic you love, and you may find in her not only a passionate researcher but also one of the most engaging listeners and storytellers you'll meet.



WHERE CELL SPEAKS IN WAVES

MODELING LIFE WITH

USHASI ROY

~Pranidhi Deshmukh

Dr. Ushasi speaks about bacteria and tissues the way most physicists discuss pendulums and potentials, and her elective “Physics of Living Systems” at IISER Pune reflects that perspective. Each lecture begins with a biological curiosity—why *E. coli* swims up a nutrient gradient, how clusters of cells decide to migrate, or why developing tissues form crisp patterns—then backs into the equations needed to explain it. Statistical mechanics and nonlinear dynamics appear not as hurdles but as a toolbox that lets students attack real problems drawn from her own research.

That research spans scales. She first modeled chemotactic bacteria, threading receptor methylation noise, phospho-protein cascades and flagellar motion into one stochastic description. The counter-intuitive finding was that maximum drift emerges where intracellular noise also peaks; randomness turns out to guide the cell rather than hinder it. Shifting from single cells to collectives, she adapted a “cellular Potts” lattice: when adhesion is very strong clusters crawl slowly, when it is too weak they scatter, but at an intermediate “fluid” regime they rearrange constantly and migrate fastest—exactly the sweet spot exploited during cancer invasion. To connect gene circuits with tissue-level behaviour she embeds toggle switches, triads and repressilators inside every model cell, lets the proteins diffuse, and watches random gene expression self-organise into domains or travelling waves. Small tweaks in diffusion length change the patch size; altering circuit motifs flips bistable patches into tri-stable mosaics or oscillatory stripes.

Ushasi’s path to this interface was shaped by a master’s summer project that revealed how physics could turn biology’s descriptive “what” into an explanatory “why.” Trained purely in physics, she keeps reading biology to stay bilingual and expects the same curiosity from her students. In project teams, she pairs coders with literature-savvy classmates so each teaches the other. Her course welcomes auditors from across departments, and post-class discussions often sprawl for an extra hour as faculty visitors and PhD candidates challenge a derivation or propose an experiment. She reminds them that all models are approximations; the art lies in choosing the handful of interactions that really matter.

Outside the lecture hall, she encourages the group to take short hikes around Pune, convinced that field air and informal talk solve equations as effectively as whiteboards. Asked why newcomers should dive into this field, she smiles: it is young, full of unanswered questions, and lets you frame those questions yourself. Her next challenge is to fuse the adhesion-based migration model with the gene-circuit framework, aiming for a single theory of how biochemical decisions drive mechanical invasion in tumours. For that, she is seeking doctoral candidates from physics, biology or anywhere in between—anyone willing to cross boundaries, ask why, and enjoy the exploration.



THE LIGHT SIDE OF MISFOLDING

EXPLORING AMYLOIDS WITH

SARITA PURI

~Soumyojyoti Pal

Sarita Puri, INSPIRE Faculty Fellow at IISER Pune, is a trained biochemist with a Master's in Biotechnology. During her Ph.D. at IIT Delhi, she tried to explore the physical meaning of spectroscopic data, connecting it to the intricate molecular mechanisms occurring inside cells. This ignited her scientific curiosity and led her to study protein folding, misfolding, dynamics, and aggregation across various model systems, including complex multidomain proteins, knotted proteins, functional enzymes, and antibody light chains during and after her postdoctoral stints at Academia Sinica, Taiwan, and the University of Milan, Italy.

Her recent works have established two key findings: first, distinct microenvironments of different organs do not alter mature amyloid structures in cases of multi-organ deposition of a single light chain, and second, a unique structural feature in amyloidogenic light chains, which includes an H-state, may serve as a potential target for protein stabilizers in future therapeutic strategies.

Her lab at IISER Pune focuses on the aggregation mechanism of antibody light chain proteins, which is associated with a lesser-known but clinically significant amyloid disease, Light-Chain (AL) Amyloidosis, where the excess light chains produced by plasma cells deposit in multiple organs, reducing life expectancy, often to six months or less. She is currently exploring how this aggregation really occurs, how naturally occurring mutations and oxidative modifications modulate the structure and dynamics of pathogenic light chains, which affect their aggregation propensity. Despite advances in AL amyloidosis research, the complex mechanisms underlying light chain aggregation remain poorly understood, and her lab aims to unravel these pathways, ultimately contributing to better diagnostic and therapeutic applications. Once her lab is fully functional, she also plans to use the cryo-EM facility to analyze amyloid fibrils extracted from patient samples.

Her lab welcomes highly motivated students, regardless of their background. Those with interests in wet-lab techniques, protein purification, and quantitative data analysis are particularly encouraged to join. She also supports students bringing new research ideas, provided they align with the lab’s core themes.

Dr. Puri describes IISER Pune as a fantastic and supportive place for new faculty. Despite challenges like research funding delays, institutional support enabled her to begin lab work from day one. She is especially appreciative of Pune’s pleasant climate, having found European winters quite difficult during her postdoc years. In her spare time, Dr. Puri enjoys reading spiritual books, finding peace and perspective through them. Currently working with three project students, she is enjoying the collaborative process of building a new lab—a fun and fulfilling phase in her academic journey.

FROM SOLAR STORMS TO STARDUST DREAMS

The Magnetic Journey of NITIN YADAV

~Sojwal Rajmane

Dr. Nitin Yadav is an Assistant Professor at IIT Delhi. Her research interests lie in Magnetohydrodynamics (MHD), the role of waves, vortices, and instabilities in the heating of the solar atmosphere, magnetic reconnection, and particle acceleration.

In a chat with her, she recalls how coming back to IIT Delhi felt like coming home. She was born in Rajasthan and studied in a small village in the Sri Ganganagar district called Sadhulsheher until her 12th standard. She was always interested in physics and mathematics and wanted to pursue a career in these disciplines. She was just 15 when she passed her 12th standard.

Finding it difficult to meet the age criteria for the IIT-JEE, she decided to pursue a BSc instead of waiting for two years. She completed her BSc at a college affiliated with Bikaner University in Sri Ganganagar. It was during this time that she first stayed in a hostel away from home. She recalls how difficult it was for her to live alone and how her grades were affected. It took her quite some time to adjust to the new environment. During her BSc, for a science day exhibition, she made a model of laser-induced fusion. She was intrigued by the concept, its applications, and the potential of this field in research.

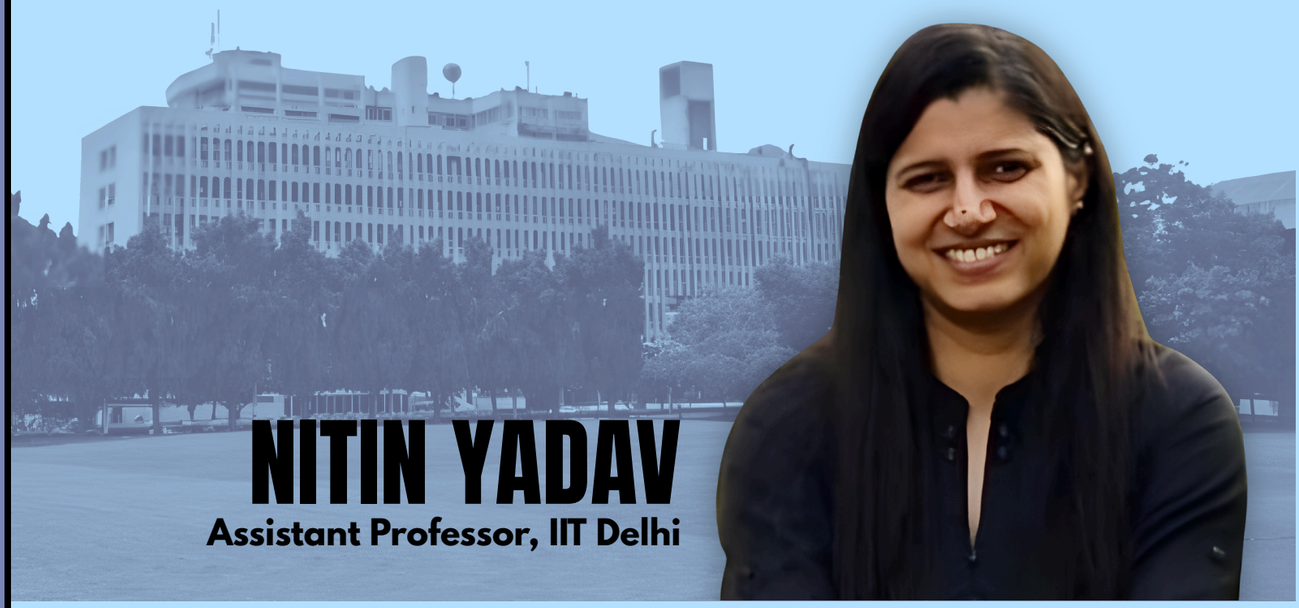
Coming from a teaching background, her family wanted her to earn a BEd degree and take up a teaching job. However, she had other plans. She appeared for entrance exams for both BEd and MSc and secured admission to Punjab University for a Master's in Physics. Her specialization was in experimental nuclear and particle physics. Later, she pursued an MTech in Energy Studies at IIT Delhi and continued with the same supervisor for her PhD and postdoctoral research. Her master's project was a theoretical and numerical study on laser-plasma interaction.

For her PhD and postdoctoral research, she shifted focus slightly towards space plasma physics. It was a purely theoretical and numerical project involving particle–plasma wave interactions using modelling. She studied interactions of various kinds of plasma waves present in the universe and the Sun–Earth system in the heliosphere, including the solar corona. Most of the applications were related to the Earth's atmosphere, such as the auroral ionosphere and magnetosphere. Later, she developed an interest in the problem of coronal heating and began applying to solar physics research groups. She joined the Max Planck Institute for Solar System Research in Göttingen, Germany, as a postdoctoral fellow, where she spent three and a half years conducting research. She says, "After going there, I really enjoyed that place. I must say that I had never enjoyed my research as much as I did there because it was a different atmosphere—working with such knowledgeable and helpful people. I really learned a lot there."

Her next postdoctoral opportunity was at CmPA, KU Leuven, Belgium, where she worked with Prof. Rony Keppens. After completing the postdoc, she joined IISER TVM as an Assistant Professor. This year, she returned to IIT Delhi as an Assistant Professor. She enjoys teaching a lot, but besides that, she also enjoys playing badminton and reading books.

The solar atmosphere can be treated as an ionized fluid, so we can use the Navier–Stokes equation. We also have the continuity equation, momentum balance, energy equation, and equations for the magnetic field. These together form the MHD equations. Solving them simultaneously helps us study the evolution of plasma in the solar atmosphere. To solve these highly nonlinear equations, we rely on numerical tools such as radiation MHD simulation codes. MURaM, for example, is a proprietary code developed by the Max Planck Institute for Solar System Research and the University of Colorado. This code has been continuously improved over the years, and many researchers are still working to make it more comprehensive and realistic. Implementing all theoretical physics numerically is complex and computationally expensive, so some approximations are necessary.

Her current research focuses on solar vortices, rotational features in the solar atmosphere. Through simulations, she investigates the origin of these tornado-like structures on the



Sun, whose existence has been confirmed through observations. She found that they are mainly associated with MHD wave propagation. Granules are convection cells on the Sun's surface, where plasma rises, radiates energy, and then sinks. In the MHD framework, if there is a rotational perturbation, it can excite torsional Alfvén waves, which are essentially rotational waves. These waves propagate their rotational nature to higher layers due to their incompressible nature. The dynamics in these higher layers of the solar atmosphere are primarily governed by the magnetic field. Any rotation in the magnetic field will also induce rotation in the plasma. She has worked on understanding how the properties of these rotational flows change under different solar conditions.

So far, her work in solar physics has been mostly simulation-based, but she is gradually expanding into observations. She believes that observational solar physics holds great potential, especially following the Aditya-L1 mission, and that the field needs more funding and people to analyze the data now becoming available.

Her future goal is to combine various plasma models into a unified simulation setup. Plasma can be modeled as a fluid or with particle-based methods like particle-in-cell (PIC), depending on parameters such as density and collisionality, ranging from collective fluid behavior to individual particle interactions. Currently, she uses fluid models, but they are limited in capturing small-scale phenomena. The typical resolution in MHD simulations is about five kilometers, whereas observational resolution is around 30–40 kilometers. However, these observations are influenced by both large- and small-scale processes. To allow direct comparison with observations, simulations must become more realistic.

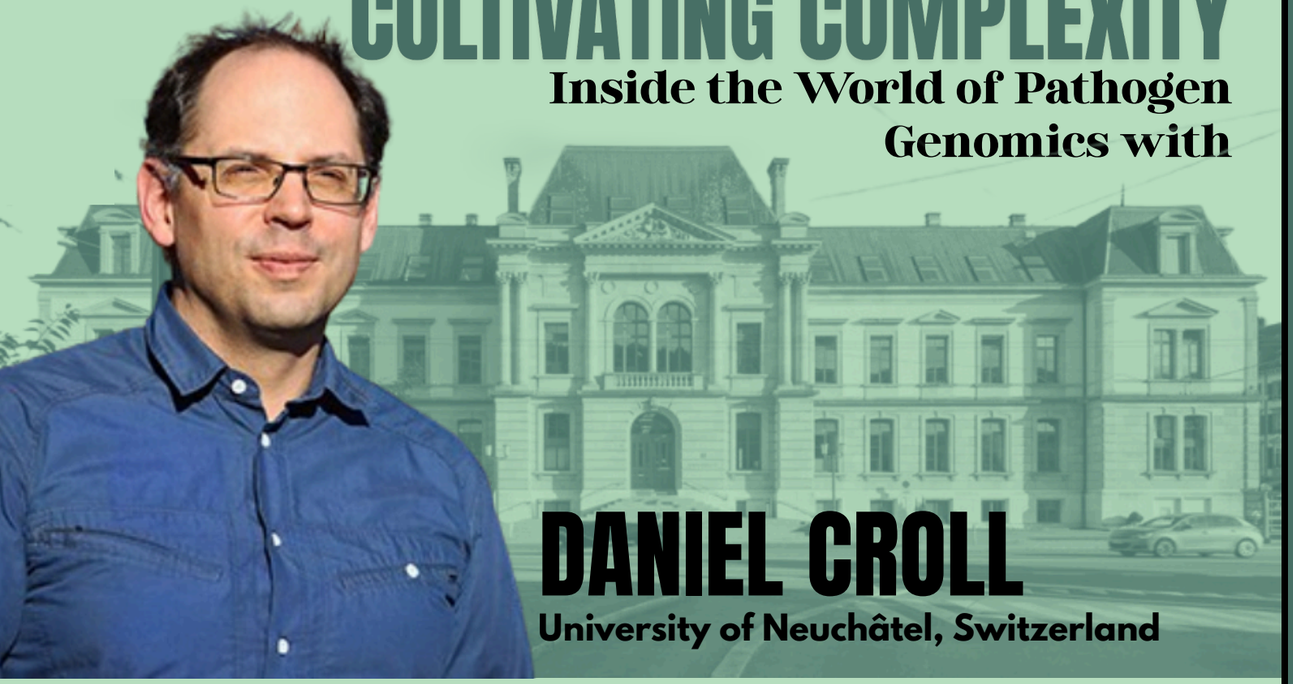
We also need to resolve the small scales where current and viscous dissipation occur. These are one of the main causes of the heating behind energetic solar phenomena. However, doing so is currently not feasible, as it requires including detailed physics for that regime, which is also computationally very costly. Particle-in-cell simulations, which study interactions at very small scales by modeling particles directly, are useful in principle. But applying them to the Sun is not practical due to the vast number of particles involved.

Her message for students is:

"Just follow your heart and do what you enjoy without thinking too much about future prospects. Many times, I hear students say that a certain field doesn't have much scope or that they want to do experimental work, hoping for industry options. But I believe you shouldn't force yourself to pursue something you're not passionate about. Do what you genuinely enjoy, because at the end of the day, that's what truly matters."

CULTIVATING COMPLEXITY

Inside the World of Pathogen Genomics with



DANIEL CROLL

University of Neuchâtel, Switzerland

Daniel Croll is a Full Professor at the University of Neuchâtel in Switzerland. After completing his undergraduate studies as well as his PhD at the University of Lausanne, Switzerland, he went for his postdoctoral studies to ETH Zürich. This was interrupted by a postdoctoral stay in Vancouver, Canada. Following this, he returned to ETH Zürich as a research group leader and was eventually offered an Assistant Professorship at the University of Neuchatel and is now a Full Professor.

His laboratory currently works on studying the evolutionary genomics of pathogens, mostly focusing on crop pathogens. The interest and focus on this field were built in a step-wise manner. During his PhD, he worked with an enigmatic group, symbiotic/mutualistic fungi, which are very difficult to analyse at the genetic level due to a lack of information and tools available to do so. Thus, he decided to move to some more amenable fungi, plant pathogens, although even research on them was in its infancy when he started working on them. His postdoctoral studies were an exciting time of generating novel genomic data for these plant pathogens and this expanded into looking at intra-species variation of pathogens and tracing the evolution of their genomes, how it has been shaped by their role as pathogens, and the appearance of resistance in these organisms.

"Why Zymoseptoria tritici?", I asked. The answer as he explained, is two-fold. Firstly, he was really fortunate that his postdoctoral supervisor was someone who had been working with this organism for a long time (since the 1990s), and had collected a lot of data that could be used to analyse the themes Daniel wanted to investigate for this organism. This data was collected very systematically by his supervisor, which was another reason it made using Zymoseptoria tritici data a tempting opportunity.

Moreover, as mentioned before, a lot of these fungi do not have software made specifically to analyse their genomes. Something the Croll Lab takes pride in, is its ability to utitlise existing tools to analyse genomic data and modify it for investigating the desired organism and themes. They are very good at using these tools in novel ways to analyse genomes or organisms others may not have previously thought of working with. However, the lab is not limited to bioinformatics analyses. There are sections of the lab working on molecular biology and generating their own ChIP-seq data as well as members doing field work on mycorrhizae and their interactions with the host. When asked about why he chooses to have a lab with such diversity in techniques being used, he elaborated on his need for independence as a faculty member. Being able to perform various kinds of studies allowed for different kinds of questions to be asked for the same subject and thus could provide a holistic outlook for the subject being looked into. And of course, going back to the point that simply not enough data for the plant pathogens being studied by Croll Lab were available. All of this fuelled the evolution of a lab that could perform almost all the steps required for their research from collecting data from field isolates, to preparing data for sequencing and analysing the data collected.

"The best science happens when you can combine these different fields.."

What gap does the work done by Croll Lab fill? Studying evolutionary processes and recapitulating millions of years worth of evolution through lab settings is extremely difficult and often unreliable. However, plant pathogens, especially crop pathogens (which are readily available) can be used to do this in a very practical manner.

"The lasting contribution of my lab is to really show these evolutionary processes in a lot of mechanistic detail, what exactly mutations are, how complex adaptation truly is, not in an artificial setting and not just in broad strokes, but actually at the exact molecular level."

With a warm smile and welcoming persona, Daniel is more than happy to take interns as well as Master's Thesis students, PhDs, and Postdocs who may want to join his lab. They are more than welcome to bring their ideas on what kind of projects (of course related to the lab's overall focus) they would like to work on and brainstorm these ideas with Daniel. The members of the group are also a welcoming bunch and there are quite a few lab outings that get planned, with everything from museum visits to via ferratas.

A work-life balance is encouraged in his group. "If you do science, it is so extremely vague what exactly you should do. It's rare that the plan is perfectly clear. A lot is creativity, a lot is your own training and thought process, and that cannot be just forced by hours." Daniel believes in focusing on the quality of data generated rather than forcing members of his group to work long hours or over holidays, a sentiment I think many would agree with.

Outside of the lab, Daniel has a wide range of hobbies and interests, including cycling. A break year between his graduation and PhD was the perfect time for him to go cycling across Eurasia, an enriching year-long experience that allowed him to really slow down and see life across various countries and cultures.

"I just had this passion in me that I wanted to see the world and I wanted to see it at the slowest pace I could still do it. I can't walk, that's too far!"

A final message for the readers of this magazine from Daniel is to not be influenced by what others tell you, but to rather trust your gut about what you want to do. Don't get told off by a bad grade or what some professor might have said about your work. But also being curious about other people's work and what gaps can be filled is an important aspect of working in science.

"If you want to have a career in science, you should have a go at it!"

~Suhani Bhattacharyya



HELICASE *Fall Edition, 2025*



WOMEN in SCIENCE

"In celebration of women who transform curiosity into discovery."

WISC 2.0



THE COMMITTEE

About the Women in Science Committee
at IISER Pune

WOMEN'S DAY

About Women's Day Celebration
at IISER Pune

WITH VINEETA BAL

Discussion with Vineeta Bal on the
Women's Day Panel

THE COMMITTEE

~ *Neha Nair, Sritama Senapati*

Behind every scientific milestone are stories we rarely hear - stories of women who broke barriers, defied odds, and are often written out of the narrative.

To be a woman in science has never been easy. From Rosalind Franklin's uncredited contributions to the discovery of DNA, to Lise Meitner being denied a Nobel Prize, to countless brilliant women being denied even a degree, every story shows a pattern of systemic exclusion. Unfortunately, such problems are prevalent even today. The Women in Science Committee (WISC) at IISER Pune aims to tackle these very issues and provide women with a support network to help them through their path in academia.

The WISC is a collective of various faculty from the campus who aim to promote gender equality by empowering women and recognising women for their contribution to scientific progress despite all the challenges they face along the way. They strive to bring about an environment where all women are encouraged to reach and realise their complete potential. The current iteration, WISC 2.0, is chaired by Sudha Rajamani and consists of

1. Pooja Sancheti
2. Kaneenika Sinha
3. Seema Sharma
4. Devapriya Chattopadhyay
5. Jeetender Chugh
6. Bijay Kumar Agarwalla
7. Shabana Khan.



GENESIS

The initial version of WISC was founded by Moumita Majumdar in 2020. Dr. Majumdar set up WISC with the aim of having a guiding force for female students throughout their career paths, be it academia or industry. An idea that was put forth to Sunil Mukhi (then the dean faculty) and Jayant Udgaonkar (then Director) soon expanded into a sizeable committee with members like Anirban Hazra, Girish Ratnaparkhi, Ashna Bajpai, and Chaitra Redkar. Anjan Banerjee was responsible for the initial R&D of the committee.

However, being set up during the COVID era had its downsides. WISC initially experienced low participation from the student population. That being said, some of the sessions on financial independence, however, did see a good turnout from the faculty and staff.

How exactly does WISC plan on achieving its goals?

Women's empowerment is not just a challenge for women to tackle. It's a collective issue that needs the engagement of the entire society. Yes, including men. Hence, WISC events are aimed at raising awareness, not only among women but also among male colleagues.

They even hold talks celebrating the works of women. Women Scientists from all over the world have come here to talk about not only their work but also their life in academia and their overall experiences.

September 11, 2024
Deepa Subramanyam
Role of intracellular trafficking pathways in cell fate, development, and disease
About the study to understand the COVID-19 based impacts on STEM and its dependence on gender and caste

September 2021
Tamalika Banerjee
Oxide Spintronics: materials and devices for unconventional computing
A rolling stone: from hills to flat land.

April 2021
Robin Fulton
Application of support nano-zero valent iron: from nitrate to heavy metal remediation
Women in STEM: Finding your feet



November, 2021
Parul Ganju
'The Business of Science: How to translate your Scientific ideas'

July 2021
Sussana Terracini
Pattern Formation through spatial segregation
My journey in mathematics

WISC 2.0

Established by Sudha Rajamani, it can be fairly said that WISC 2.0 has shown measurable progress. Other than hosting more talks and events, WISC 2.0 has many further events planned down the line. To gain further insights into the functions and workings of WISC 2.0, we sat down for a quick talk with Prof. Rajamani.

One of the main goals of WISC 2.0, according to Prof. Rajamani, is to offer special fellowships, jointly with Dean R&D, for women PhD students and young mother faculty. Current PhD funding does not accommodate maternity/childcare leaves, placing female students at a great disadvantage. For this reason, the WISC can grant financial assistance to these students for 6 months. This fellowship is also expanded to young mother faculty who often miss out on peer support, time to apply for grants, and networking opportunities by attending conferences.

Another goal of WISC 2.0 is to bring together women from across the campus and hold biannual gatherings of women staff (faculty, admin, contractual workers) to discuss their problems in an informal setting. The committee has planned for such a meeting to take place in mid-August 2025.

Releasing a gender audit and conducting gender sensitisation talks is another goal that WISC 2.0 aims to achieve. In fact, the original WISC had held gender sensitisation talks, but it was later discontinued due to the minimal turnout. Gender sensitisation is a crucial component of gender equity movements. It helps eliminate gender discrimination by challenging existing gender roles and stereotypes that are prevalent in society. Prof. Rajamani believes that these talks must be given within the first few months of the students being on campus, and must be made mandatory. "We need to catch them young," she stated.

WISC doesn't include a BS-MS student body or representative, and this more than often reflects in the negligible participation of BS-MS students in WISC events. When asked what we could do about this, Prof. Rajamani proposed the plan of having a peer group among the BS-MS students: "*There can be a peer group that exists among the BS-MS community members who are, sort of, the interface between the WISC committee and students. Possibly to at least bring to us some of the issues that you [BS-MS students] are facing, because we tend to hear the most about issues that are faced by IPhD and PhD students*".

WOMEN'S DAY CELEBRATION

Dates: March 3–8, 2025
Venue: IISER Pune Campus (LHC & C.V. Raman Auditorium)

~ *Rupsa Chatterjee*

INTRODUCTION

To commemorate International Women's Day (IWD) 2025, the Women in Science Committee 2.0 (WISC 2.0) at IISER Pune organized a week-long series of events aimed at celebrating the contributions of women in science, acknowledging the journey toward gender equity, and catalyzing further discussions and actions toward inclusive academic spaces. The initiative, in line with this year's IWD theme ***#AccelerateAction****, brought together faculty, students, and staff to engage in meaningful activities designed to inspire and inform.*

EVENT HIGHLIGHTS

Collaborative Student Club Events

WISC 2.0 partnered with two dynamic student clubs to host themed events that combined fun with reflection:

Quiz Club – "Women's Day MNQ"

Date: Monday, 3rd March | Time: 9:00 PM
Venue: LHC 103

The Quiz Club curated a special quiz titled "Women's Day MNQ", focusing on women in science, history, literature, and pop culture. The event saw enthusiastic participation and engagement from across the student community.

Winners:
First Place: *Berry [Aditya Moger] and Chris; Goutham and Narayanan*
Second Place: *Govind and Aanantha*
Third Place: *Sreejita and Mridul*

Literature Club – "Feminism Through the Ages" [Hosted by Ananya Parvati and Kshreya]

Date: Friday, 7th March | Time: 5:00 PM – 7:00 PM [Rescheduled to 11th March]

This event explored the evolution of feminist thought through literary works, speeches, and performances. It offered a creative platform for students to reflect on feminist milestones and express their interpretations.

Memorial Talk and Panel Discussion

Date: Wednesday, 5th March
Venue: C. V. Raman Auditorium
Memorial Talk on Prof. Rohini Godbole
Time: 4:30 PM

The day began with a heartfelt memorial talk delivered by Sunil Mukhi, commemorating the life and contributions of the late Prof. Rohini Godbole—a pioneering physicist and advocate for women in science. He reflected on her scientific legacy and her enduring impact as a mentor and change-maker.

Panel Discussion: "Accelerating Gender Equity in Academia and Allied Fields"

Time: 5:00 PM – 6:20 PM

The panel brought together a diverse group of professionals who shared personal insights and systemic challenges that persist in academic and research institutions. Moderated by Vineeta Bal, a long-standing advocate for equity in science, the discussion addressed barriers to representation, proposed actionable strategies, and emphasized community-driven change.

INSIGHTS FROM THE PANEL DISCUSSION ON ACCELERATING GENDER EQUITY IN ACADEMIA AND ALLIED FIELDS

~ *Suhani Bhattacharyya*

'Panel Discussion: In addition to collaborating with two student clubs to bring you the aforementioned special events, we have a thought-provoking panel discussion on Wednesday, 5th March (5 pm to 6.20 pm). Relevant to this year's IWD theme (#Accelerate Action), the panel discussion will be on "Accelerating Gender Equity in Academia and Allied Fields". We have a great line up of panelists who will bring their experiences from diverse work spaces to discuss how we can come up with effective solutions to various gender related issues that still persist in our work environments! The panel discussion will be moderated by our very own Prof. Vineeta Bal, a scientist who has been working for many decades in the space of facilitating effective processes to help alleviate issues that women scientists face in academia.'

An excerpt from the email sent to us by Sudha Rajamani about the Women's Day 2025 activities on campus. Curious about this, I sat in the C.V. Raman hall to go on to listen to an insightful discussion about implementable methods to help women scientists with the issues that many of us face in academia. Rather than going into detail about every point discussed, through this article, I would like to highlight three of the most important points brought up during the discussion, regarding which I later had the chance to have an even more detailed discussion with Vineeta Bal.

Gender Sensitisation meetings

Overcoming the lack of awareness about what is and is not ok, and what are the problems women face in this field, is one of the most important steps to take in promoting gender equity. Not just problems women face, but the pressure men get put under, such as, to be the bread-and-butter winner for the family is also something promoted by the patriarchal system. Getting equal pay for women in the workforce such that their income supplements and adds to the family income is a huge benefit that most people do not seem to be aware of.Regular and compulsory to pass, perhaps annual, gender sensitisation meetings conducted every two years for every single person who is a student or working in the university is the only way to successfully conduct and spread awareness about certain basic guidelines. Systems like this are already in place in many institutions abroad. The point is not to immediately change the mindset of people, but rather, as Prof. Bal puts it, get people into the habit of doing things and making scientists who are supposed to be thinkers, think. Conducting such meetings should be done by professionals who are in the field of women's studies from outside the institution and these would need to be enforced by committees such as the IC within the institution. For this, demands from students for such regular meetings is an important step that many of us should consider taking.

Affirmative action for women

In JNU University there used to be a system where for a certain program, some points would be given based on your background. If one was from an underprivileged background, certain points would be given called 'deprivation points'. A woman from a similar background to a man would be given some of these deprivation points. Doing so resulted in much more diversity in JNU than when this program did not exist. People have this conception that having affirmative action means men are being treated unequally. However, all these programs and actions do is account for the privilege men and those from advantaged backgrounds have. One might question whether this is unfair, especially in a field like science where all that should matter is the research. However, society plays a role in the responsibilities it puts on everyone. The woman is expected to cook and take care of the home while also working. Not only that, in committees where due to the smaller ratio of women in the field, it is often that women in academia have to manage multiple committees along with their research administratively, while also having to take care of their homes. This puts a lot of pressure and things such as deprivation points simply account for the additional pressure put on people from various backgrounds. For those who may think that those who get into institutions through affirmative action are maybe not as capable as those who do not, the GATI program in IIT Delhi saw students brought in through affirmative action were at par with those who were not. To measure the extent of affirmative action, periodic surveys are essential, something which is not the norm but needs to become the norm not just at the institute level, but nationwide.

Incentives in academia and industry

This is not comparable in generalised terms. However, from the panel discussion, one of the speakers from an industry seemed to put forward a lot of incentives that their industry provides, which I have personally not seen in the academic institutions I have looked at. But the only way to know this for sure is to collect data and do surveys. A more important point is whether these incentives are bringing about genuine change. They may help in the short term, but using the argument from gender sensitisation meetings, the hope is that once people get into the habit of doing things correctly, they actually think about it and it becomes second nature to them.

Having women in positions of power whether it is through incentives or affirmative action allows them to have a say and bring up more women to those positions of power. This increases diversity, something which is important in general but also crucial to the advancement of scientific research and society as a whole.

"*Is it not frustrating to have to take so many baby steps?*", I asked. As Prof. Bal put it, a sustained fight, starting with negotiations and just spreading awareness is required and hopefully change will follow.

SCIENTIFIC TALKS BY WOMEN RESEARCHERS AT IISER PUNE

Date: Saturday, 8th March
Time: 10:00 AM – 4:30 PM
Venue: Madan Mohan Malviya Hall

The final event of the week-long celebration was dedicated to showcasing the scientific work of IISER Pune's women researchers. This all-day event featured a series of talks highlighting their research across disciplines. The initiative aimed to amplify the voices and visibility of women scientists within the institute, especially for those whose work may not yet have been widely shared in internal forums.

Schedule of Talks:

1. *Dr. Sarita Puri - Biology Department*
2. *Dr. Zainab Amin - Chemistry Department*
3. *Dr. Shamin Padalkar - Science Education Department*
4. *Dr. Tresa Mary Thomas - Earth and Climate Science Department*
5. *Dr. Moumanti Podder - Mathematics Department*
6. *Dr. Swapna Joshi - Humanities and Social Sciences Department*
7. *Dr. Surabhi Jaiswal - Physics Department*



CONCLUSION

The IWD 2025 celebrations at IISER Pune, led by WISC 2.0, successfully created an inclusive space for dialogue, celebration, and action. Through collaborations, memorials, academic showcases, and thought-provoking discussions, the events emphasised both recognition of progress and commitment to furthering gender equity in science and academia. The week was a meaningful tribute to the contributions of women scientists, a reflection on historical and ongoing challenges, and a call to collectively accelerate action toward a more inclusive future.

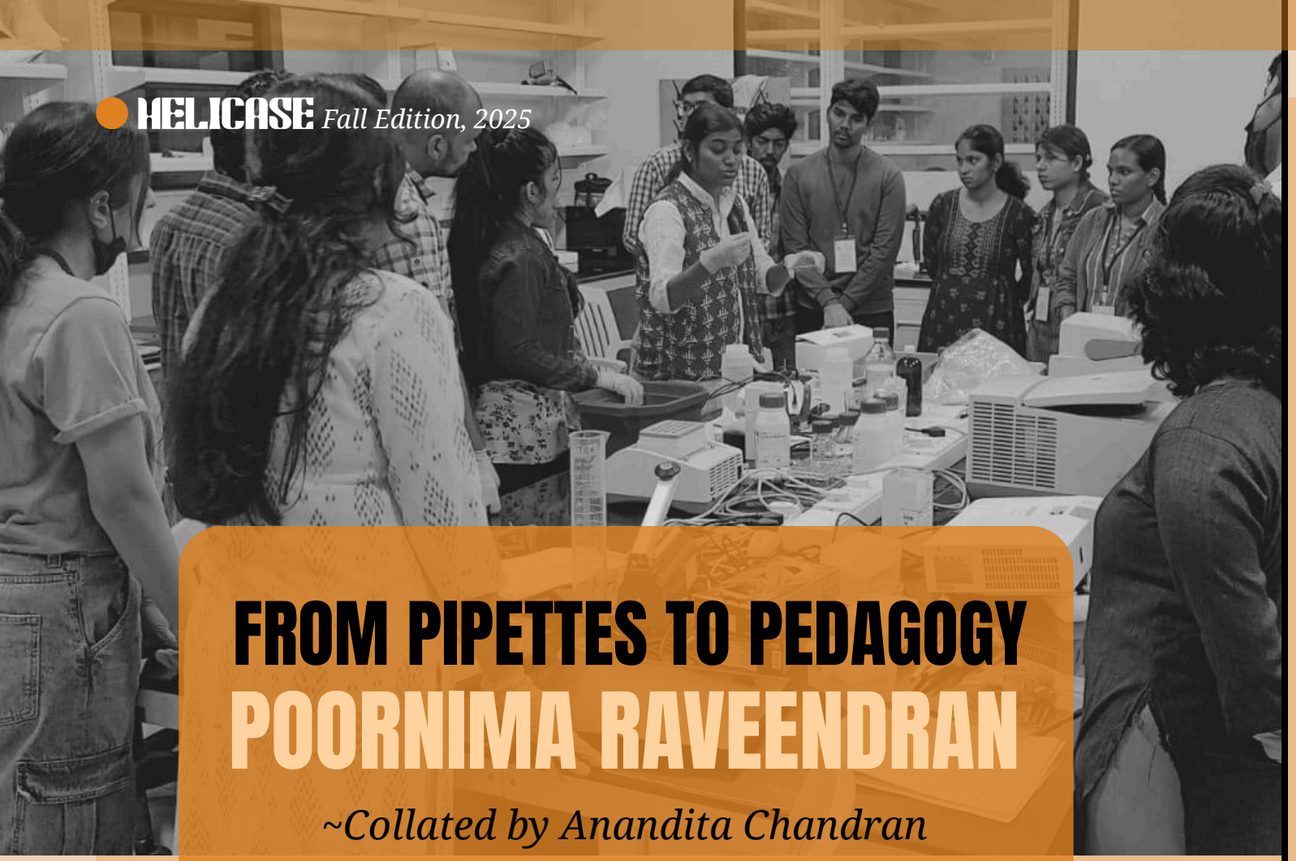
To conclude, committees like WISC are an integral part of supporting women scientists not just locally, but all over the world. However, one must note that the WISC does not deal with harassment issues. Such issues will be addressed by the Internal Committee. WISC solely aims at sensitising the population. So perhaps one day, with sustained effort and shared responsibilities, we can build a future where women researchers will have an equal chance to contribute and lead in various scientific endeavours.



HELICASE *Fall Edition, 2025*

Breaking the GLASS ~~CEILING~~ *beaker*

Insights into the Careers and Lives of Women Researchers at IISER Pune



FROM PIPETTES TO PEDAGOGY

POORNIMA RAVEENDRAN

~Collated by Anandita Chandran

I am a biology educator interested in experiential learning via the biology laboratory. I work as a Senior Teaching Associate at the Indian Institute for Science Education and Research (IISER), Pune since 2019 and was actively involved in teaching IISER's undergraduate biology lab course from 2016-2019. In my current project, I have trained over 2600 undergraduate and high school students interested in learning hands-on molecular biology experiments.

I completed my Masters (Botany) and have a professional teaching degree (B.Ed), both from Pune University, India. My biological research experience is from National Research Centre for Grapes, Bhabha Atomic Research Centre (BARC), Mumbai and Department of Zoology, Pune University.

What brought me into science...

was the usual cliché that 'if one has above average to good marks one should pursue science'. Unlike a lot of people around me now, I also think it took me a long time to accept that I am happy doing science. However, I continue to be fascinated with the natural world around me, beginning as a small child when my mother would tell me stories about giant reptiles that roamed the earth, larger than the huge rain tree in our small garden. Of course, only couple of years down the line Spielberg made Jurassic Park and what my 6-year-old brain tried to imagine, came terrifyingly alive on the big screen where a team of scientists used genetic manipulation as a tool to re-create these extinct reptiles.



The first time I felt it was worthwhile to pursue research...

was during my Masters and I went to the Department of Genetics, South Campus, Delhi University for a summer project. The first time I experienced working at a research lab with many PhD students, post-doctoral fellows doing very interesting work in plant genetics. I was also told in no uncertain terms that the project that was assigned to me by my supervisor, Prof. Sujata Bhargava at the Department of Botany, Pune University (now SPPU) was grand and way beyond M.Sc. student level. I was assigned to complete a two-step cloning in under two months and this was back in the time when we did not have access to too many fancy kits or cloning techniques. I was elated to have completed 50% of the job i.e. the first step of cloning but due to lack of time I had to return to Pune for my M.Sc. classes. I also had excellent mentors here; Dr. Soumen Nandy and Dr. Esha Bhattacharya who definitely made my first close encounter with Molecular Biology extremely interesting. On returning from DU, Prof. Bhargava encouraged me further by assigning me a master's thesis project where I had to work at the transcriptome level in jowar under physiological stress, thereby doing a lot of RNA and RT-PCR work. I am thankful for these experiences and interactions that definitely had a very positive impact on me. I never would have guessed back then that 20 years down the line, MolBio would become my bread and butter.

My inflection point into teaching...

was after a tumultuous period due to unsatisfactory experiences I had as a research student. I completed my professional teach-ing degree and focused on teach-ing Biology to classes 11 and 12 at Abasaheb Garware College, Pune. This was a very satisfactory period of my professional life as I was finally doing what I always wanted to do: teach students and learn how to be better at it with every class. While teaching here, I got the opp-ortunity to work at IISER-Pune as a teaching assistant in the undergrad biology lab and I took a leap into the unknown. Why do I say so? To push oneself out of one's comfort zone is one of the most difficult things to do in life!



At IISER Pune...

began chapter two of my professional life: biology laboratory and experiments. Although it was not easy to make this shift and adapt to research-based teaching, I kept working at it, honing my skills to teach hands-on lab. As I spent more time with the students (and experiments), it dawned on me that teaching and research do not exist as separate entities. The joy of connecting the dots of theory using the experience one gains in the laboratory is beyond words. Isn't this one of the core principles of biological research? I ask you to pause reading for a few seconds to scan your own memory drive and identify the exact moment/ moments when you fell in love with science?

More often than not, it is while making these connections between scientific theory and practice. Hence, according to me, isolating theory from practical experience is a grave injustice to all the students.

I appreciate this all the more because many students after attending the hands-on workshops have come back to IISER and shared how a particular workshop or lab course helped them in better understanding the theory. The other factor that ties research and biological experiments is troubleshooting and trying to figure out what went wrong. This is a life skill whose importance I cannot emphasize enough because it is applicable to all aspects of our daily life. Trial and error is one of the important foundations of addressing a particular question/problem and the more one is comfortable with this, many solutions offer a helping hand to address the said question/problem.



As a woman in science observing the seasons change ...

I think I am definitely blessed to be born in one of the better times for women in general. Having worked at a state university, local college and a research institute, there has not been an incident where I noticed or was made to notice my gender or it had any implications on my work. There is a possibility this is because teaching is considered as a 'normal' career for a woman. However, I am aware that my peers who have had families and breaks in their careers, do find it harder to come back into main stream scientific research.

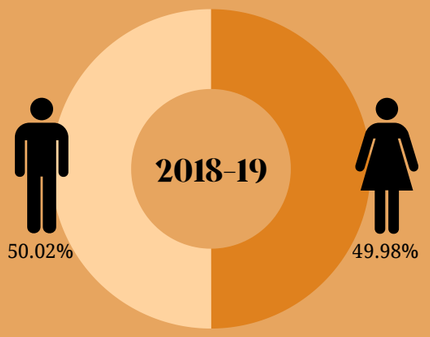
In terms of importance, teaching is considered by many (not all) as a poorer cousin of research. In our society, there is a hierarchy of importance where research and related training > college teaching > school teaching> kindergarten teaching. And one may argue that it has to do with quantity/quality of work, intellectual capacities needed to perform each work etc and we may choose to agree or disagree with that.

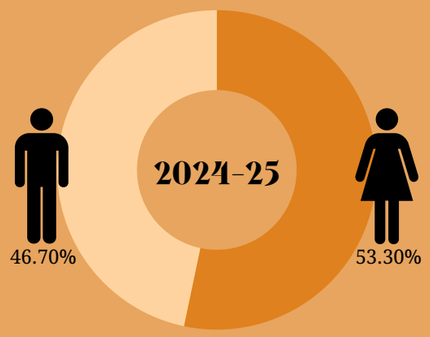
However, there is one more practical factor that plays into this mentality: finances. Looking at the bigger picture in India, it is a well-known fact that school teachers are paid lesser in comparison with college teachers and faculty working in the Higher Education Institutes (HEI). In 2023-24, female teachers made up 53.3% (52 lakh) of all Indian school teachers, up from 49.98% in 2018-19. Male school teacher numbers apparently have dropped to roughly 45 lakhs.

The Indian EXPRESS

Women teachers dominate India's school teaching workforce in sharp contrast to higher education: Report

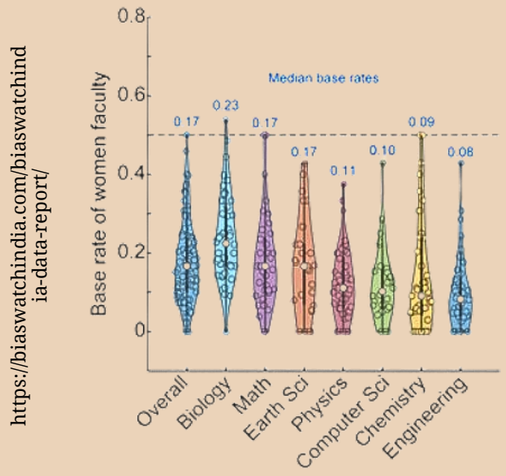
However, a closer look at the UDISE+ data reveals that the gender gains made in school education are mainly on account of private schools, where the increase in female teachers has been much sharper.





https://indianexpress.com/article/education/women-teachers-steadily-overtaking-men-driven-by-growth-in-private-schools-data-9760439/





In HEI, the following graph from a 2023 article by BiasWatchIndia2 tells the story of the overall base rate of women faculty in Indian academia as 16.6%

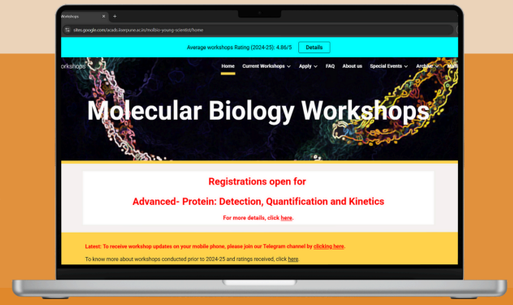
In a stark contrast, in Myanmar**3**, jobs which require higher education such as law and teaching are populated by women because they attract little prestige and are poorly paid. Typically, male dominated careers, including politics and farming do not require university education and attract higher pay. So, the bigger picture definitely shows that collective efforts are needed to bring any major shift in societal perspectives regarding women pursuing science as a vocation.

I cannot conclude my IISER journey without acknowledging people who have helped me regain my interest in research and integrate it within my teaching. I am thankful to BSMS batches 2015-16-17-18, Dr. Neelesh Dahanukar, Dr. Krishanpal Karmodiya, Dr. Raghav Rajan, Dr. Nishad Matange and Prof. Sudha Rajamani with whom I worked closely for the undergraduate lab sessions. I am grateful to Prof. Sutirth Dey for having given me this unique and ever-evolving opportunity to conduct so many different workshops for a huge spectrum from high school students (9th-12th), biology undergraduates and PhD's, doctors and even BTech students.

I think that laboratory work is extremely important along with the theory that students' study especially in biology and chemistry. The experience I have gained in different undergraduate lab settings since being a part of the IISER ecosystem has enriched my life in more ways than I can count.

For more details about my current work:

https://sites.google.com/acads.iiserpune.ac.in/molbio-young-scientist/apply/iiser-pune-hostel-accomodation



MolBio_Workshops

A LIFE IN NUMBERS

KANEENIKA sinh(a)

~ Saranya Ray

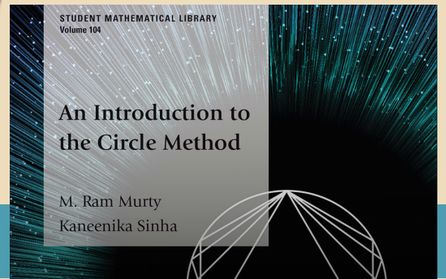


Mathematics often evokes various reactions–fascination, fear, or frustration. However, for some, it is a lifelong passion, a language of patterns and logic that leads them to a career in research and teaching. I recently had the privilege of interacting with Dr. Kaneenika Sinha, an Associate Professor in the Mathematics department at IISER Pune. She shared insights into her journey through academia, her research, and the culture of inclusivity fostered at the institute.

"I enjoyed Mathematics in school," she recalls. "While I did not know then that it could be a career, I saw it as a subject central to many paths." That early interest blossomed during her undergraduate years, when she participated in programmes like the Mathematics Training and Talent Search (MTTS) and the Visiting Students Programme at the Tata Institute of Fundamental Research (TIFR), Mumbai. These experiences cemented her desire to pursue an academic life focused on research and teaching.

Her current research lies at the fascinating intersection of probability and number theory, using tools from analysis to address deep mathematical questions. "The distribution of prime numbers is a recurring theme," she says, "but similar patterns emerge in sequences tied to other arithmetic objects–modular forms, elliptic curves, exponential sums, and even regular graphs." It is a space where abstract thought meets surprising applications, unified by an underlying sense of mathematical structure.

At IISER Pune, she has taught a wide array of courses, ranging from foundational subjects like linear algebra, probability and discrete mathematics to advanced PhD-level topics. One course particularly enjoyed designing was in additive number theory, which eventually led to a co-authored book on the circle method with M. Ram Murty, published by the American Mathematical Society.



During the pandemic, she also delivered a course on Probabilistic Number Theory, which remains available on IISER Pune's YouTube channel. "This semester, I will be teaching a course in real analysis to third-year students," she shares. "It is a foundational course. My aim is to challenge the students and introduce them to the rigour behind mathematical analysis."

A long-time faculty member at IISER Pune, she reflects on how the institution has prioritised inclusivity from its inception. "Our founding administrators saw all members as equal stakeholders in building the institute and valued every voice," she notes. "That culture has only grown stronger." She highlights two milestones in particular. First, the creation of an on-campus day-care centre, initiated by Dr. Mayurika Lahiri, which allows parent-scientists to work with peace of mind. "Few Indian institutions have maintained such facilities over time," she says. Second, she recalls a moment in 2014 when women students raised concerns about inappropriate comments from staff. "Professor Sunil Mukhi, then Dean of Student Activities, took immediate action by calling a joint meeting of the entire security and housekeeping establishment. We discussed the issue openly, and the staff responded with reflection and change." Such instances, she believes, reflect the proactive and respectful environment that defines the IISER community.

Outside the realm of mathematics, she finds solace in literature. "I love reading English and Hindi works. I am absolutely enamoured by the Brontë sisters-particularly Charlotte Brontë." Her interests also include history, political narratives, and mathematical biographies. A regular at the campus gym, she also enjoys evening walks–often spotted strolling through the campus, pausing to capture its natural beauty through her lens. Yoga is also a part of her routine, helping her maintain a sense of balance and well-being.

She is the voice behind Academic Garden, a blog she began during her early faculty days at IISER Kolkata. "I had so much to share but no one who would listen!" she remarks. Though it started anonymously, her identity as the blogger quickly became an open secret, especially after moving to IISER Pune, where many students and colleagues referred to the blog in conversation.

Some of her fondest memories from graduate school revolve around her teaching responsibilities. She began teaching full courses during her PhD, and those experiences left a lasting impression. She fondly recalls students showing up to support her during her thesis defense, and older students kindly offering to drive her to the doctor when she wasn't feeling well. One particularly memorable moment came the morning after St. Patrick's Day, when several students turned up to class visibly hungover, much to her quiet amusement. Beyond the classroom, she also cherishes the deep friendships she formed with people from diverse cultures and life experiences–connections that enriched her academic journey and personal growth.

She was among the youngest scientists invited to a meeting with Prime Minister Modi. "It was a great experience," she says. "He emphasised collaboration and addressing real-world challenges like climate change and nutrition. It gave me insight into how policy and science interact."

As faculty coordinator for the student-run Maths Club, her role is primarily administrative. "I mainly forward emails and sign reimbursements, but I love their energy. Their enthusiasm is infectious, and my mood lifts whenever I meet the club members."

She offers a candid and heartfelt perspective to aspiring women mathematicians who may feel discouraged by the field's male-dominated reputation. "Based on my interactions with our women students, I can say with reasonable confidence that most of them do not get deterred by this factor. To be very honest, I wish I had the kind of gumption that I see in them when I was their age." She believes that once one embarks on the journey of doing mathematics, the intricacies and challenges of the subject itself become the primary source of focus and motivation. "There will be professional and personal ups and downs, and there are so many factors that we cannot predict in our journey. However, as long as we love mathematics, we give it our best. We keep going and cross each hurdle as it comes, one at a time."

Whether through her research, teaching, or mentorship, she continues to inspire students with her passion for mathematics and her commitment to making academia a more inclusive and welcoming space. As someone navigating the world of STEM myself, I found this interaction both enlightening and deeply encouraging.



BRAINS & BEYOND

MRIDULA GARG

~ Raafia Shaikh

We often imagine that a career in research begins with a clear plan or a lifelong ambition. But for Dr. Mridula Garg, the journey began with a superhero film and growing up in a household with two doctor parents. Science was always around in the form of colorful encyclopedias and novels but it was a screening of 'The Amazing Spiderman' that gave rise to a vague fascination. Watching Peter Parker's brilliance and his life as a scientist left a surprisingly strong impression on a young teenager. "That was probably the first time I started imagining myself as a researcher," she says living out her 12-year-old self's dream (without the Spidey-sense and Web-shooters :P).

Years later, despite a deepening interest in the sciences, the choice after school came down to two very different paths – research at IISc Bangalore or medical school at Maulana Azad Medical College (MAMC) in Delhi. Like many 18-year-olds, the decision leaned towards the safer, more familiar option because med school seemed like a secure choice, especially within a family already rooted in medicine. During medical school, a growing fascination with the central nervous system began to shape everything. Right in the first year, a physiology course taught by Dr. Satyanarayan left a deep impression, and over time, the brain became her favorite organ system to study. She still recalls how during clinical rounds, while most classmates hoped to avoid neurology patients, she would actively volunteer to examine stroke cases. "Understanding the brain, for me, has become essential to understanding who I am," she often says. Rather than memorizing drug lists or case protocols, the core mysteries of neuroscience became more compelling to her – how the electrical activity of the brain gives rise to our reality, and how its imbalances lead to mental health disorders and neurological diseases.

Her inclination for research led her to reach out to Prof. Debashish Chowdhury, Head of Neurology at her institute. Even as the country was under lockdown, she would shadow neurologists in the outpatient clinics and wards, growing ever more resolute in her dream to study neuroscience. During her final years at MAMC, she worked with him to study chronic migraine patients.....

That growing urge to explore how the brain works rather than just treating its symptoms gradually steered her toward research and away from clinical practice. After completing her MBBS, she joined Dr. Nixon Abraham's lab at IISER Pune as a research fellow, where she has been working for the past several months. Her current research focuses on olfactory working memory in mice, a form of short-term memory used for everyday tasks, like remembering a one-time password or navigating a new place. The team studies how environmental factors like early-life stress or enriched surroundings impact memory and sensory perception. The larger goal is to understand how the brain rewires itself in response to life experience, and what that might mean for children growing up under difficult conditions.

Before her time at IISER, she had already engaged in research. During her final years at MAMC, she worked on a study involving chronic migraine patients, exploring if non-pharmacological approaches, particularly behavioral changes led by education alongside drugs, could improve symptoms and quality of life. Patients were guided through the biology of their condition, and their health beliefs were addressed head-on. The findings were encouraging: small, structured conversations led to meaningful improvements in both headache severity and quality of life. "It's a tiny step towards more holistic care," she says. For her, it exemplifies how medicine is a lot more than just drug prescriptions, and how empowering patients to understand their bodies truly brings about meaningful change.

At IISER, she's had the chance to work with advanced neuroscience tools, including optogenetics – a technique that allows scientists to control specific neurons in the brain using light. Light-sensitive proteins, borrowed from algae, are inserted into targeted brain cells, which can then be switched on or off with precise flashes of light. The technique is one of the reasons she was drawn to the lab in the first place. The team also uses methods including calcium imaging and electrophysiology, which allow researchers to listen in on the brain's electrical signals, in essence, the internal exchange of information between brain cells.

For her, neuroscience feels like a perfect field that demands creativity, interdisciplinary thinking, and constant curiosity. There's a sense of awe in studying how the brain gives rise to not just thoughts and emotions, but consciousness itself. Often, she describes it as "a 3-pound organ, sealed in darkness inside the skull, somehow constructing our entire reality." Neuroscience allows her to connect her love for biology with long-standing interests in physics, maths, and even philosophy.

Apart from the lab, she likes playing basketball or going to the gym, occasionally picking up the acoustic guitar or sometimes even painting. She also loves writing and runs a little blog of her own where she often writes about the brain and some random philosophical musings. The rhythm of life at IISER suits her – from long walks under leafy canopies to spontaneous lab outings and post-experiment CCD coffee runs. The lab itself is tight-knit and refreshingly low on hierarchy. It never feels like a workplace to her, more like a group of friends geeking out over cool ideas. Having spent just under a year at IISER Pune, the place already feels like home. The peaceful, green campus has been a refreshing change from Delhi's fast-paced cityscape, and Pune itself has offered its share of charm, especially in the form of cozy cafés and long walks.

Looking ahead, she hopes to pursue a PhD in neuroscience, with a particular focus on brain rhythms and altered states of consciousness such as sleep, coma, and meditation. The idea that attention and mental training can reshape brain activity is an exciting frontier. Ultimately, the goal is not just to do research, but to connect it to people's lives, helping them make more informed choices about health and well-being.

Reflecting on her unconventional path, she acknowledges that choosing research wasn't easy, especially after years spent training for a profession often seen as one of the most secure and prestigious ones. But over time, it became clear that fulfillment doesn't come from external validation, instead, it comes from doing something that feels meaningful to you. For students unsure about pursuing science, her advice is grounded in experience rather than idealism. It's not about having all the answers at once, but about listening to what excites you and being open to uncertainty. "Life is all about doing things that are difficult, but things that you love," she says — a quiet reminder that passion and perseverance often matter more than any set plan.



MRIDULA NAMBIAR

~ Smera Thejasri M T

SKETCHES OF SCIENCE

We often imagine life-changing moments as dramatic turning points – a big decision, a major event. But most of the time, the small things add up to turn one's life around. For Dr. Nambiar, now an Assistant Professor at the Department of Biological Sciences, IISER Pune, it was a visit to the Center for Biotechnology (now known as IGIB) in Delhi that sparked her fascination with research. While in school, Dr. Nambiar was always interested in Science, especially Biology. After completing her 10th standard, she participated in the CSIR's "Youth for Leadership in Science" program. A trip to the Institute of Genomics and Integrative Biology (IGIB) left a lasting impression "That was the first time I was introduced to the world of research, and it played a major role in shaping my decision to pursue research as a career," she recalls.

Today, Dr. Nambiar's research focuses on understanding the molecular underpinnings of chromosomal segregation defects that can give rise to aneuploidy during meiosis and mitosis. These defects have direct implications for understanding the causes of human infertility, genetic disorders, and cancers. Her team is currently investigating how centromeric recombination generates aneuploid gametes upon completion of meiosis. They are also exploring the mechanisms behind differential cohesin loading across the genome in a region-specific manner, influenced by the varied composition of cohesin complexes within cells. In addition, they are identifying epigenetic factors that facilitate this differential cohesin loading, aiming to understand the mechanistic basis of segregation errors and their broader effects on transcription, DNA repair, and genome architecture. Currently, Dr. Nambiar's lab works with a yeast experimental model system. But they dohope to start mammalian cell culture experiments soon.

"What excites me most is how fundamental these questions are," Dr. Nambiar says, "and the depth of mechanistic understanding we could achieve using a relatively simpler but still very complex experimental model such as yeast." Looking ahead, Dr. Nambiar wants to explore the conservation of the molecular basis that they decipher here in the context of human genetic diseases and cancers.

Outside the lab, Dr. Nambiar finds creative release in sketching, painting, and doodling. "I find it very relaxing," she shares. She is also an avid reader, although she admits it has been difficult to make time for books recently. One of her fondest scientific memories comes from her postdoctoral days. After nearly a year of diligent effort, she finally observed a specific phenotype in a set of mutants she had been working on.

"I still remember the day it happened and the excitement with which I rushed to my postdoc advisor to tell him. That one result was instrumental in shaping my postdoctoral research as well as some aspects of my current work", she recalls.

Lab activities are also part of her lab routine, whether they are dinners for celebrating achievements or farewells or just a semester-end outing with everyone who worked in the lab. They have also been to Escape rooms, which she recalls, were thoroughly fun to do as a group.

Looking back to her college days, Dr. Nambiar admits her younger self would be surprised to see her now, confidently teaching a large class of undergraduate students. She recalls a funny incident from her undergraduate days. "I remember once my whole class (~20) decided to bunk a lecture and go for a movie and it was important that everyone went or at least didn't attend the class, to show a united front. However, I refused and stayed in class to attend the lecture. Ultimately, they also couldn't go and many of them didn't talk to me for a while. I have become much more chill since then." These stories make one realise that every small or big event in our life will one day become a story to be told.

Her advice to students? "***Life can be overwhelming, but it is easier to get through with friends. Also, it is okay to be different and not follow the crowd. Doing things you like and putting in a sincere effort in whatever you do is all that matters.***" But the journey isn't without challenges. Dr. Nambiar admits that she also struggles with her version of self-doubt and imposter syndrome. "***Support from family and close friends certainly helps. Also, at work, all the efforts by people in my lab keep me motivated and get me through tough days***", she says.

Dr. Nambiar draws inspiration from the late Prof. Angelika Amon, whose pioneering research and kindness left a deep mark. "I have been in awe of the simplicity yet cleverness of her experiments and scientific ideas, which always inspires me in my research." But it's also the everyday victories – new data, a fresh result, the camaraderie of her lab - that keep Dr. Nambiar's passion for Science burning bright.



SUSMITA ADHIKARI

OF HALOS AND HORIZONS

~Anargha Mondal

In a heart-warming chit-chat with the Science Club, Dr. Susmita Adhikari from the Physics Department of IISER Pune opens about dark matter halos, dance, and humanising science.

"I think I have moved around a lot," Dr. Susmita Adhikari begins, her voice both nostalgic and animated as she maps out her early life. Born in Bombay, she spent her childhood shifting between Oman and India before eventually settling in Calcutta. "I was born in Bombay, went to school there for the lower classes, and then we moved to Oman. I came back to Bombay again, but around class 4, I moved to Calcutta." She pauses thought-fully. "I had spent some of my more conscious years in Bombay, but moving to Calcutta was really, really, really very formative in many ways."

It was Calcutta that truly shaped her intellectual and cultural identity. Speaking about her love for the City of Joy: "Even as a child I could see that the world system is very different. It places a lot of premium on knowledge rather than wealth. That makes you grow into a more rounded individual." Her college years only deepened this appreciation. "In Calcutta, you know, there are students who come in from all over the state (for undergraduate education). So, there is a good amount of diversity in the kind of backgrounds that people come from, rather than the school, rather than my school level. Because it was much more beautiful that way."

Susmita's connection with the arts has been equally enduring. Dance, in particular, holds a special place in her heart. "The first time I joined a dance class was actually in Oman," she says with a smile. "When I moved to Calcutta, I was learning Bharatanatyam and started performing a lot in school programs." She admits her early training was informal: "I picked up the first vertices from my classmates, fellow performers. Later, I got formal training. Now I think I've had at least four years of formal training, and I'm still continuing."

Her family, too, played an instrumental role in shaping her worldview. She describes her sister as a firecracker of creativity: "She's a very colorful character, much more dramatic than I am." The contrast between their interests, Susmita's in science, her sister's in the humanities, opened up important conversations at home.

"My father was like, 'You just have to do science.' But my sister helped me question why we think some directions are somehow better." These dialogues fostering debate over the hierarchies of academic interest shaped a big portion of her upbringing, according to her. Susmita speaks warmly of her mother's strength and support: "She grew up in a very restricted environment but has always been very liberal. She's drawn from me, and I've drawn from her.

By the time she reached class 11 or 12, Susmita had found her footing in physics. "I realized that I like physics and can do well in it," she remembers. In college, that initial interest , which started with reading up on stellar evolution in school, blossomed into a deeper commitment. "There was a lot of space to sit down and study your own thing, apart from having some very good professors." One professor, in particular, made a lasting impact. "He taught us mathematical methods. The way he approached problems was so unique. He wouldn't teach from the book but would take one problem and discuss various aspects of it. I really started enjoying trying to understand why you do what you do." Elaborating upon her interests in the physical sciences: "I was always interested in astrophysics and quantum mechanics. During my masters in Bombay, I worked on black hole thermodynamics." Yet she remained intellectually curious and flexible: "I enjoyed many other different parts of physics."

The transition to the U.S. for her PhD was as challenging as it was eye-opening. "It's the first time you start living independently. You start appreciating life and the little things more." She was immediately struck by the academic culture. "You feel like you're at the forefront of your field. You learn about the newest things as soon as they're out, debate them, discuss them."

Despite the excitement abroad, her heart remained anchored in India. "That was a decision I had made even before I went. I wanted to work in India. I knew the education system here closely and saw myself fitting in more meaningfully."

Joining IISER felt like a natural step. "I always found the student body in India very dynamic. Teaching also keeps you on your toes. It's good to keep in touch." She takes pride in designing and delivering a range of courses—from first-year mechanics to advanced astrophysics and cosmology. "Designing a course is quite challenging, but it's much more fun to teach high-level courses. Just because the classes are smaller and you can actually interact much more with the students."

Her research dives deep into the structure of the cosmos. "We study how dark matter, dark energy, and the standard model of cosmology evolve. How do galaxies form? How do they evolve in the gravitational potential of dark matter halos?" Her group bridges theory and observation, including collaborations on ambitious projects. "We recently joined the Rubin Observatory, which will observe almost half of the sky."

Despite her demanding academic life, Susmita carves out time for joy. "I love unwinding. My appetite is based on when will I unwind?" she laughs. Dance and food remain her favorite outlets. "I love cooking and eating. Dance is not merely a professional endeavor. It's part of my understanding."

Books, too, offer refuge and reflection. "I like reading all kinds of books, both fiction and non-fiction. I started reading Bengali literature in college. Recently, I read a book called America, about the experience of 90s immigrant students in the U.S."

When the conversation turns to gender equity in physics, her tone becomes thoughtful. "The student culture has definitely changed. Students are much more conscious now, especially about gender issues. But at the faculty and committee level, there's still a long way to go."

She highlights the importance of outreach. "We should try to attract students to physics, especially women. At IISER, we get so few women undergraduates in physics now. There are programs, but we need to evaluate how well they work."

Among the women who've inspired her, she names a true pioneer. "Vera Rubin. Her measurements were the ones that set off dark matter science. We don't discuss her enough." She also recalls mentors from her own career. "My postdoc advisor was a woman. She was a very inspiring character. Another mentor once told me, 'You don't have to be like everybody else. You can be yourself and still do science.'"

Nearing the end of the conversation, she offers one final reflection for budding scientists. "Do it if you enjoy doing it. Research is a long-term commitment. It's a character-building exercise. You need patience and integrity. But if you love it, there's nothing quite like it."

HELICASE *Fall Edition, 2025*

PORTRAIT OF A COMBINATORIAL STORYTELLER



MOUMANTI PODDER

~ Parth Sarda

"Never forget what you are; the rest of the world will not. Wear it like armor, and it can never be used to hurt you."

Raised in a Kolkata household where quantum riddles and elegant proofs floated across the dinner table, Moumanti Podder seemed destined for a life of ideas. Now an Assistant Professor of mathematics at the Indian Institute of Science Education and Research (IISER) Pune, she is celebrated for her work on probabilistic methods in discrete mathematics and for the warmth with which she mentors future combinatorialists. Soft-spoken yet unmistakably driven, she often calls herself "married to my work," a declaration delivered with a disarming smile that fuses sincerity and confidence.

Early Spark and Family Influence

Both of Podder's parents are physicists, and their constant intellectual curiosity ignited her own. During high school she oscillated between the abstractions of physics and the crystalline logic of mathematics, ultimately realizing that the latter "felt more like home". She credits her parents' resilience and guidance for showing her that scholarship is less an occupation than a way of living.

Academic Odyssey

ISI Kolkata
Podder completed her B. Sc. and M. Sc. in Mathematics at the Indian Statistical Institute, one of India's principal crucibles for mathematical talent. There she plunged into discrete mathematics, attended her first conferences, and even met Joel Spencer—the legendary probabilist who would supervise her doctorate.

New York University
For her Ph.D. she moved to New York University, relishing the freedom to think at odd hours and the guidance of Spencer, whom she still calls "family". "We had no restriction on work timings; we often worked until late at night," she recalls, noting that the city's vibrant mathematical community made it a "perfect place" for a young combinatorialist.

Post-Doctoral Years
Post-doctoral appointments at Washington University and Georgia Tech widened her collaborative network, and a research stint at the National University of Singapore added an Asian chapter to her cosmopolitan trajectory.



Research Landscape

At IISER Pune Podder explores problems at the interface of probability, graph theory, and combinatorics. A current fascination is the elephant random walk, a stochastic process whose next step depends on the complete history of its past—a memory-laden creature she studies through Fokker–Planck equations with collaborators in Germany. She also teams up with Urban Larsson of IIT Bombay on combinatorial game theory, analyzing graph games from a purely combinatorial viewpoint rather than through classic game-theoretic machinery. What unites these projects is her delight in "puzzles that look trivial—like the Pigeonhole Principle or Burnside's Lemma—but conceal astonishing depth."

Teaching Philosophy

Podder teaches third-semester Probability and fourth-semester Discrete Structures, courses she regards as conceptual bedrock for later specialization. Her classrooms are conversational spaces where a carefully sketched proof can segue into impromptu discussions about research horizons. She hopes to introduce advanced electives on random graphs and Markovian statistics, mirroring her research palette. Following her doctoral mentor's example, she organizes informal gatherings with her PhD students, convinced that mathematical intuition often blooms in relaxed settings.

Return to India

Despite attractive prospects abroad, Podder left the United States, uncomfortable with what she terms the "perform or perish" culture tying funding and job security to relentless metrics. Indian academia, she felt, offered greater peace of mind and proximity to family—even if it meant fewer resources and lower salaries. When IISER Pune invited her to join immediately—a year earlier than a competing offer from IISc Bangalore—she accepted, encouraged by conversations with future colleagues Kaneenika Sinha and Soumen Sarkar.

Future Directions

Most of Podder's forthcoming papers will orbit "combinatorics on graphs": elephant walks on evolving networks, game trees underlying novel graph games, and the probabilistic behaviour of random graphs endowed with memory. She hopes her students will cultivate a similarly broad toolkit, blending rigorous combinatorial reasoning with probabilistic flair.

Life Beyond Equations

- Podder calls herself a "workaholic", yet unwinds by sketching and doodling whenever she finds free time.
- She devotes countless hours to practicing Indian classical vocal music, finding that disciplined riy¯az balances her analytical work.
- An avid runner, she has completed several half-marathons and maintains a regular training schedule.
- Together with her husband she rescues and cares for injured stray dogs; one such dog recovered under her care at IISER Pune.
- She believes that making art disciplines the mind in ways that complement mathematical creativity, echoing remarks she has made in earlier interviews.

Counsel to Aspiring Scientists

Quoting Tyrion Lannister, Podder urges students to know themselves and "wear that knowledge like armor". Whether that identity is shaped by late-night proofs, marathon runs, or caring for injured strays, she believes authenticity is the surest defence in a career full of stochastic motion.

SUNEETA VARDARAJAN, a Professor at IISER Pune, is a leading theoretical physicist specializing in black hole physics and gravitational phenomena. Her research covers classical perturbation theory and quantum aspects of black holes, with significant contributions to understanding nonlinear instabilities in spacetime. This interview explores her scientific journey, research insights, and her experience at IISER Pune.

BLACK HOLES AND BEYOND

~ Parth Sarda



Research Inspiration and Background

Why research? Prof. Vardarajan's fascination with theoretical physics began during her B.Sc (Hons.) at St. Stephen's College, Delhi, followed by an M.Sc at IIT Madras. Her Ph.D. at the Institute of Mathematical Sciences solidified her passion for gravitation and mathematical physics. A lot of her inspiration came through due to her family, who were supportive of her during her early career, and also they inspired Prof. Vardarajan as they were both working in academia in the fields of Chemistry and Physics. They acted as a primary source of motivation. Prof. Vardarajan remembers reading Hawking's paper on Black holes' singularity and it being a motivating factor in her choosing this field.

Field specialization: She chose black hole physics for its unique blend of geometric elegance and physical predictions, particularly phenomena like Penrose's singularity theorems and Hawking radiation. Her postdoctoral work included positions at LMU Munich (Alexander von Humboldt Fellow), University of New Brunswick, and University of Alberta before joining IISER Pune in 2010.

Research Contributions

Core investigations: Prof. Vardarajan's group studies:

- Classical black hole perturbation theory (for astrophysical signatures)
- Quantum features of black holes
- Nonlinear instabilities in matter propagation through spacetimes

Novel approaches: Her work employs analytical techniques to predict instability conditions in anisotropic spacetimes, notably investigating anti-de Sitter (AdS) stability in string theory. She has developed models examining:

- Ricci flow effects on black hole stability
- World-sheet RG flow dynamics
- Large-D limit perturbations of black strings

Why this field matters: "Black holes are cosmic laboratories where general relativity and quantum mechanics collide," she emphasizes. Recent developments like the Event Horizon Telescope's direct imaging (2019) validate decades of theoretical work while opening new questions. She, speaking of the result, talks about the challenges of such a result, and how this paints an elegant picture about the blackhole.

IISER Pune Experience

Courses: Since joining in 2010, Prof. Vardarajan has taught courses including:

- Gravity
- Mathematical Methods for Physics
- Advanced Gravitation
- Differential Manifolds

Courses she is interested in taking in the future:
She would like to take the Quantum information course. Generally. A lot of the ideas of the course we also use in Black hole research, and I have been wanting to take that course for some time now.

PhD culture: Her research group prioritizes collaborative problem-solving, with regular discussions exploring connections between gravitational physics and mathematics. She enocurages students to *"think geometrically about physical problems"*. She appreciates people with such intuition and is noted to pick the people who share the goals she holds dear. She quotes, "PhD is a long journey". Hence, it matters who you have as your PhD students.

Institutional environment: IISER Pune provides exceptional freedom for curiosity-driven research, she notes. She is a big fan of the undergraduate programme at IISER Pune, and applauds the students for asking nice questions in her courses and their curiosity.



Research Evolution and Future Directions

Field transformation: When Prof. Vardarajan began her career, observational evidence for black holes was indirect. Also, a lot of techniques that are used today, like the Von Neumann Algebra (which she suggests simplifies a lot of mathematical operations). Also, the changes in the Quantum field theory techniques(suggestion of packing of 3D space in 2D) and transformations that enable you to do that. Today, gravitational wave detections and black hole imaging provide unprecedented validation. She supports these empirical advances but cautions: "We must retain mathematical rigor while interpreting observational data".

Ongoing projects:

- Stability analysis of AdS-type spacetimes
- Nonlinear effects in black hole perturbations
- Quantum signatures in semiclassical gravity

Future goals: Her group aims to develop unified frameworks for predicting spacetime instabilities across classical and quantum regimes, with particular focus on holographic principles connecting gravitational theories to quantum field theories.

Message to Aspiring Scientists

"Build the right set of connections, they help in taking you far and wide".

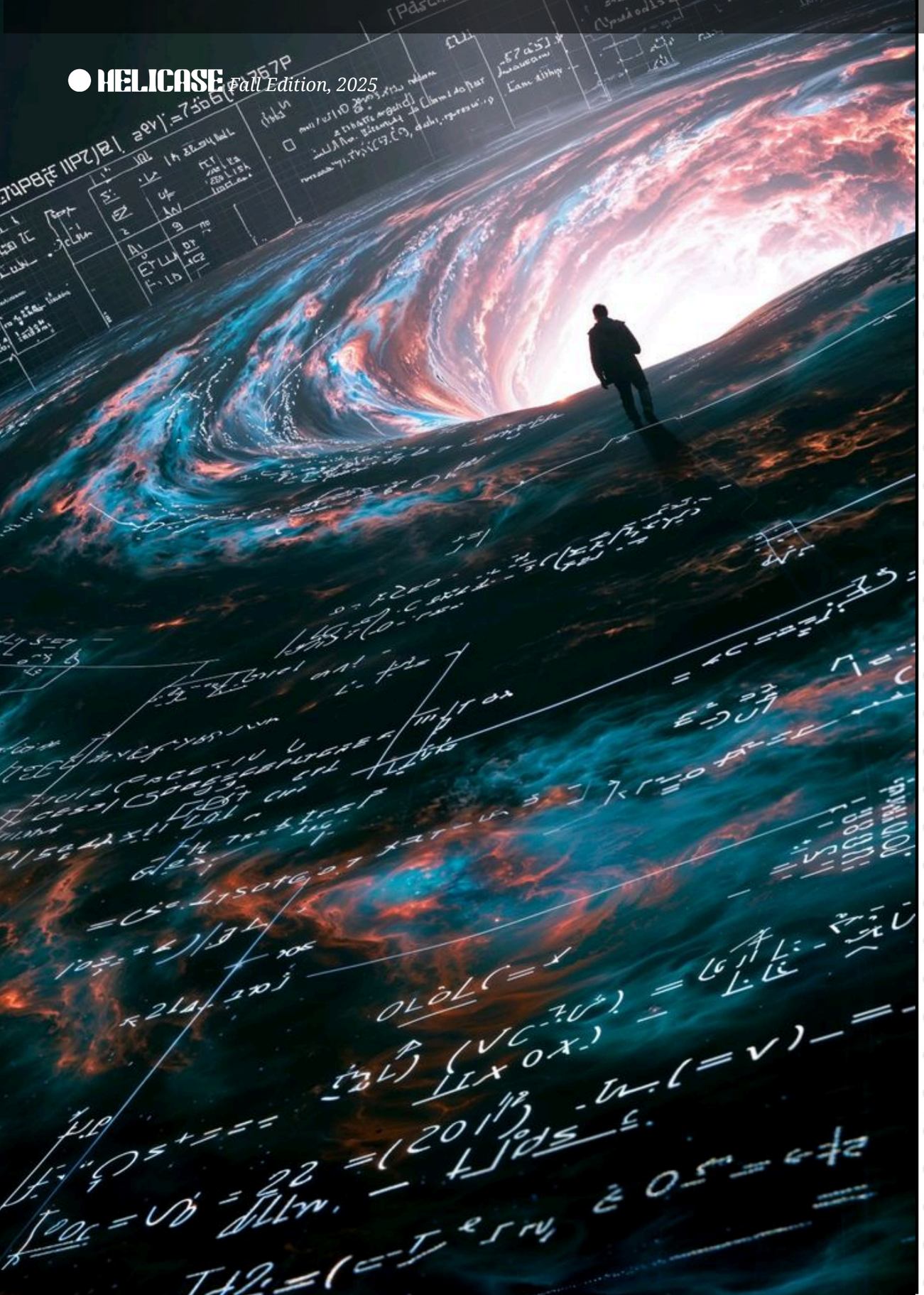
Especially for all the young women entering the scientific world, it is essential to have the right set of connections that support you. *"Embrace deep curiosity,"* Prof. Vardarajan advises.

The most profound discoveries arise from questioning apparent contradictions, like how black holes radiate while trapping light. Pursue problems that fascinate you, not just fashionable ones.

HELICASE *Fall Edition, 2025*

CURRICULUM UNPLUGGED

Courses at IISER Pune



MARKOV CHAIN

AND ITS APPLICATION

Suhani Bhattacharyya

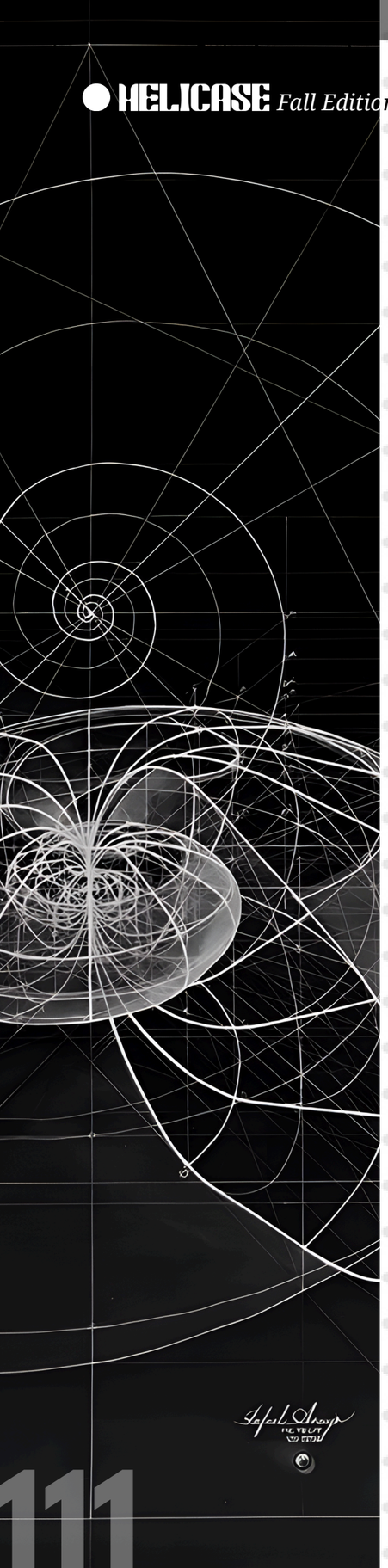
A Markov Chain or a Markov process is a stochastic process describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event. The course, 'Markov Chain and its Application' has been conducted on occasion during the years before. During the 2024 August semester, I had the chance to opt for this course, conducted by Dr. Somnath Pradhan from IISER Bhopal via an online portal. As a biologist, I found unexpected use of the applications of Markov Chains in papers such as those involving the modelling of virulence factor expression in Plasmodium falciparum with respect to the human immune system's defence against this pathogen. This course is being offered during the August 2025 semester again, taught by Dr. Anup Biswas whom many may already be familiar with from previous semesters.

As explained by him, the initial part of the course covers topics like distribution, conditional distribution, etc. which all the students have seen in their first course on probability. Two-thirds of the course has new content, including a detailed study of Markov chains (both discrete and continuous). Important examples such as the Gambler's ruin problem, Branching processes, and birth and death processes will be discussed to make students comfortable with the concept.These topics are a starting point to get into other topics such as operation research, stochastic control, and mathematical finance. It is needless to say, this course itself will not fully prepare you for these topics. To draw an analogy, real analysis is necessary to do research in analysis, and one has to go far beyond real analysis to read a research article in the area of analysis.

In accordance with this, some suggestions before taking this course would include the first course on probability (that is, Introduction to Probability). Dr. Biswas recommends students take the Real Analysis course as well before taking this course and would suggest it for third-year BS-MS students who are interested in operation research, stochastic control, and (broadly) applied probability. This course covers topics that are crucial to building/describing probabilistic models of several practical problems, including previously taught topics such as the Poisson process. When asked about what improvements his version of the course will have, he told us that the second course on probability (which IISER Pune offers in the 4th year) has Markov chains (discrete) in its syllabus, but the portion of Markov chains they could cover is very minimum. Therefore, the existing courses are not able to introduce some of the key topics of probability, aligned to operation research, in particular. This course is supposed to fill that gap.

The significance of this course is described in Dr. Biswas's words: "After spending nearly 5 years on my PhD thesis, which was based on stochastic analysis and partial differential equations, I went to work on queueing theory. I personally found that area fascinating and relatable. We use queueing model not only in canteen/cafe/movie counters but also in every click of our mouse, in every touch on our smartphone screen, in the video that play on YouTube, hospital emergency services, call centres, and many more. I am sure some of the takers of this course will get onto operation research for further exploration."





INTRODUCTION TO PROOFS

Saranya Ray

Introduction to Proofs quietly made a comeback as a 3rd semester elective for this upcoming Fall semester after being off the radar for a few years. I didn't take the course, but I chatted with Dr. Steven Spallone, who will teach it, to understand what it's all about and why it's back.

The course was initially meant for 4th sem students, designed for folks who didn't necessarily have a hardcore math background but were curious about how math really works beneath the formulas and calculations. It's now been reintroduced earlier in the curriculum, and though it's still an elective, it may become a core course someday.

It's not about doing a bunch of sums or cramming the night before an exam. This course dives into the logic behind math: truth tables, predicates, proof by contradiction, induction, and sets. There's also the formal treatment of functions, and depending on how things go, even some abstract algebra, number theory, and a taste of analysis, along with some philosophy of Math.

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Dr. Spallone was clear - this isn't just for the "math kids." It's for anyone who wants to understand the “why” behind the subject. That said, making it accessible is a challenge, considering that the TAs may not have taken the course themselves, and students get intimidated by the formal language.

Still, it's a bold attempt to offer something different that focuses more on thinking clearly than just solving problems quickly. Spallone hopes it'll help students build confidence with abstract ideas, not fear them. Whether you're a math major or just math-curious, this course is a great way to see the subject from an entirely new angle. It's the kind of course that reminds you math isn't just about answers but about how you think.

DISEASE AND DISCOURSE

Angad Singh

It is a humanities course at IISER Pune, offered in the odd semesters to third and fourth-year students. It is taken by both Dr. Nishad and Dr. Pooja together. One conducts from up on the stage, and the other sits in, often adding comments and context.

As described very well in the course outline on the drive, the course covers many different aspects of understanding disease, with the bulk of time devoted to covering infectious pathogenic diseases, including Tuberculosis, and plague, with the second half of the semester dedicated to HIV/AIDS. Nishad’s lectures will take you beat by beat through the most relevant biological details of diseases that directly inform the history, spread, treatment, and burden on people and society that we tackle in Pooja’s lectures. The course will show you how interdependent science and society are, and change how you perceive both.

Of course, this will only work if you diligently keep up with the readings shared in advance. Both professors’ provided material is interleaved and ordered to perfectly guide you through. The readings are slightly large-sized extracts and excerpts, and they cannot be treated as optional, as many classes (especially Pooja’s) are centered around the discussion of the assigned readings. The best way to keep track of the discussion is to put yourself in the middle of it. There is a novel assigned for the second half, which it is best to have read at least half of by the midsemester.

Neither the provided material nor attending the classes by themselves will be sufficient (as it may be for many courses), as the course aims to build a large and complex network of ideas from pathogen biology to social stigma. This only happens when the information that you swallowed as preparation is melded together during the narrative-building style lectures.

This course achieves the most immersive and natural flow of topics, but naturally, the two classes in a week will not be able to thoroughly wade through all the topics. This is not a bug, but a feature, that I implore you to embrace by continuing the discussions outside of class with your peers. The assessment consists of one small assignment, one mid-semester exam, one quiz, one group presentation, and its corresponding individual report.

The group project and report for the end semester immediately give you a chance to do your own deep and multilayered analysis of a disease, which will reinforce the approach of the course. Diseases are profoundly affecting society and people, and the course will give you the critical thinking required to ask the right questions about them. You will walk away having achieved exactly the objectives detailed in the course outline.

The course may complement your understanding of both the Public Policy and Disaster and Society courses, also offered by the HSS department. The course also goes well with Introductory Immunology. You can plan to take the course in either your 3rd or 4th year, as it is not a very taxing course. Both Nishad and Pooja are incredibly smart teachers, and over the course of the discussions, they will surely rub off on you and improve how you can think and communicate on any nuanced topic in the future.





SCIENCE-ING SEX

Harshal Pandit

The humanities and social sciences department is known to experiment with the inclusion of courses just about every year. Because of this, probably one of the most innovative and engaging courses, simply titled: 'Scienceing Sex in Modern India' came about. An HSS course that did not have any continuous assessments whatsoever, but still boasted more than 70 percent attendance in just about every lecture. Although it explored a niche topic, it was popular enough to have well over 100 students enrolled in it. But what made this course content so attractive and lectures so engaging that students just could not have enough of it? Well, as most people in science would say, I only have guesses, as elucidated below.

At its core, Scienceing sex in modern India was geared towards the understanding of the perceptions of sex and its 'science-ing' in early 20th century India. Dr. Shrikant Botre's first few lectures were to set the historical, political, and ideological background - like the concept of martial races introduced by the British - for the subsequent discussion about how sexual 'science' was explored. Then we went from European scholars, their viewpoints and schools of thought, and how these in turn influenced their counterparts in India. We then established the backgrounds of some of the most prominent scholars who wrote about sexuality in India and explored the various components of the sexual sciences discussed by the intellectual elite throughout history, and how they influenced and were influenced by contemporary politics, ideologies, and social groups. These components included marriage, virginity, love, eugenics, birth control or contraception, perversion, the packaging or presentation of said knowledge, family planning, obscenity, queer sexuality, and so on.

What made this course stand out was how we had almost no way of just naturally stumbling upon most of the content, which made attending the classes that much more important. It was not uncommon to see a few genuinely baffled faces (mine included) during the class. The instructor knew how to keep the whole class engaged at all times. Many others who were able to take this course share my opinion that his class was very well structured. Despite the tendency of such a topic to polarize, he was easily able to maintain a neutral and objective stance when presenting the data, which is not very easy to do. This went a long way in motivating novel critical thought about a topic that is normally regarded as taboo in most Indian households. Nobody knows why this course has not been repeated since, although most who took it would advocate for all of its good qualities. All we can do is hope a course like this returns as an elective in a future semester.

EPIGENETICS

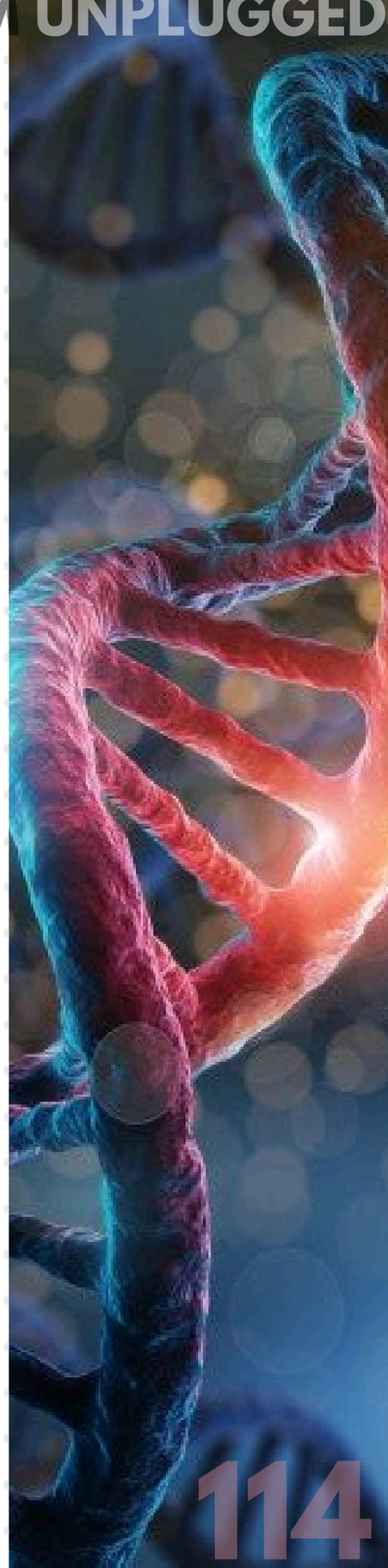
Suhani Bhattacharyya

Epigenetics is a new and modified version of the Genome Biology and Epigenetics course previously taken in the even semesters. It is available to be opted for by BS-MS students in semester 5 and 7 as well as those in semesters 9, 11, 13 and 21. There are no pre-requisites for this course.

What is epigenetics? Sequencing of the genome has revealed that sequence information is not enough to know enough about regulation of genes. In eukaryotes, the nucleus has our genome packaged in repeating units called nucleosomes consisting of DNA and histone proteins. Epigenetics is the study of modifications in organisms caused not due to changes at genomic level but rather due to inheritable changes in gene expression caused due to external factors modifying and controlling this expression. There are methods such as histone acetylation, methylation, DNA methylation as well as tools to tag DNA such that regions can be recognised to be regions of high or low expression and such marks can be inherited. This coding varies from cell type to cell type and results in virtually infinite permutations and combinations to code for expression in a particular cell. This course will also look at the effect of diets and transgenerational inheritance to see the effect of nurture on expression of genes. The question of nature vs. nurture is one that has plagued humanity for a long time. The study of epigenetics helps in understanding how environmental factors can influence gene expression without altering the sequence and how this is inheritable.

As someone who is extremely interested in this topic, I would recommend it for all those who are interested in understanding and discovering this relatively novel field in biology as well as to those interested in neurobiology, immunology, developmental biology and evolutionary biology. This is a field of study which is often overlooked and underappreciated, considering the huge impact it has on the phenotype of organisms. Why are baby monkeys scared of snakes? Do twins separated at birth really have different phenotypic organisation from each other as compared to those who are raised under the same conditions? Why do rats in with anxious mothers grow up to be anxious (or humans, for those who may relate)? These are all questions that the field of epigenetics provides insights into.

The way epigenetics has shaped our genome is extremely interesting to look into and worth taking for anyone interested in research of diseases and cancer as well. For those interested in the field of systems biology, the networks formed due to epigenetic factors is an intriguing template to model and provides vital information for biological modelling. This course is recommended for all those interested in learning about the organisation of genes and the molecules regulating them, and I especially am really looking forward to taking this course during this semester.



WHY? WHAT? HOW?

Special Courses Offered by the Mathematics Department

Dhruv Jajodia

In the list of courses, we see some maths courses like “Topics: Mathematical Finance”, “Topics: Symmetry and Lie Groups”, and “Topics: Computational Number Theory with Sage”. These are the special “Topics” courses.
Regular courses in the maths department are mostly taught so that students are well prepared for competitive exams at the post-graduate level, and to cover foundational topics that are necessary for all mathematicians. This is why they’re offered every year. But there are some topics that are important for students who want to work in some fields that aren’t covered in these regular courses. The maths department thus decided to introduce one-time courses that are taught if students want them.
As professors and students interact in talks, events etc., students tell professors if there are any topics that many students want to learn but that isn’t taught in a regular course. Or sometimes many students want to learn very similar things from theory projects. In such situations, if a faculty member is ready to, the department offers a “Topic” course to teach this subject.
If no faculty member is available to teach a topic, the course can’t be offered. On rare occasions, the department has invited a guest lecturer in the past. For example, Dr Pallavi Manohar was invited to teach a course in game theory and optimisation.
Last semester (January 2025), 3 topics courses were offered:

A. Topics: Mathematical Finance
B. Topics: Symmetry and Lie Groups
C. Topics: Computational Number Theory with Sage



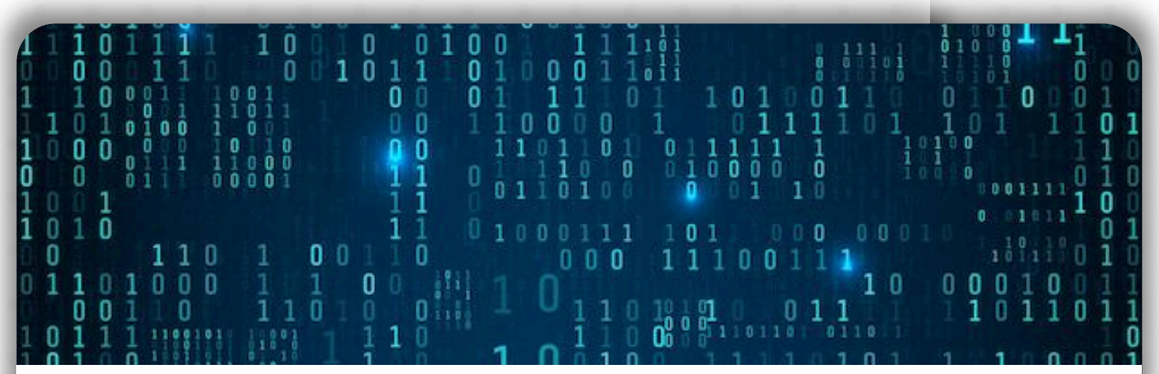
Mathematical Finance was taught by Dr. Anindya Goswami. Several students approached him to learn mathematical finance from theory projects. So, he decided to offer the course. It prepares students who want to do research work in stochastic processes (since the course teaches applications of theory of stochastic processes) and students who want to work in finance in industrial jobs. It also helps students understand finance in general for working in industrial jobs.
The course covers 3 main points:

1. How is money appreciated with time?
2. What is portfolio optimisation?
3. What is fair price of option?

The course doesn’t go into great mathematical detail, but the students are expected to be well-versed with Calculus-1, Calculus-2, and Probability, which are all compulsory introductory courses in the first 2 years.
Dr. Anindya Goswami suggests students who want to study mathematical finance to opt for other courses related to stochastic processes and probability along with this. This helps develop an actually useful understanding of the subject. An example is the Markov Processes course.



Symmetry and Lie Groups was taught by Dr. Anupam Kumar Singh, Dr. Abhishek Sarkar and Dr. Navnath Daundkar. This course served as a bridge between “Group Theory” in the 4th semester and “Differential Geometry and Lie Groups” in the 7th semester. Similar courses in algebraic geometry have seen large numbers of students in the past, so such courses are offered whenever possible.
The course starts by defining the concept of symmetry as a distance preserving function which maps a set to itself, then classifies symmetries of the plane. Later, they moved on to defining topological manifolds and smooth manifolds and finally Lie Groups. Rotations of 3-dimentional real vector space were classified as a Lie Group. For future iterations of the course, the instructors have taken student feedback and plan to replace some of the more technical parts from the end of the course.
This course, in dealing with symmetries and rotations, is useful for many fields of study other than mathematics. These include particle physics, aerodynamics, crystallography etc.
Quaternions, a 4-dimensional space with multiplication, is used heavily in research into artificial intelligence. Since the mathematical detail is somewhat limited, and the focus is on providing an introduction, it is not too heavy for those who don’t want to get deep into the theory. It still provides a bridge into deep theory for those interested.
While taking this course, students are expected to have some familiarity with metric space topology and the compulsory 1st and 2nd year maths courses



Computational Number Theory with Sage was taught by Dr. Vivek Mallik and Dr. Baskar Balasubramanyam. Some years ago, a course on elliptic curves was taught, which included some coding, though the course was mostly theoretical. The students enjoyed the coding parts, but found it quite hard since they had to jump to implementing hard algorithms after their only formal course on computing the introductory course in the 1st semester.
So, the idea behind “Computational Number Theory with Sage” was to provide something easier while keeping it oriented towards number theory. Many number theoretic algorithms are implemented in Sagemath already.
This course gives the students a strong foundation in coding if they want to apply for industrial jobs, and gives them a way to try to solve number theoretic problems computationally if they do research projects in number theory. This is helpful in making conjectures since many calculations are too complicated to do manually. So, to be able to employ computer software to solve complicated mathematical problems is an essential skill for many professions.
All prerequisites are covered in the compulsory courses in the first three semesters, or as and when required during the course itself. This time in teaching the course, the theory and (computer) lab sessions were kept separate, which the instructors intend to change in future courses that have a similar aim.

And that’s it for now, since there aren’t any topics courses in the August 2025 semester. Interact with professors and keep an eye out for interesting one-time courses in future semesters!



IISER Pune Science Education Department

Sojwal Rajmane

The Department of Science Education at IISER is one of the institute's most recent and exciting academic additions, established in 2021, shortly after the pandemic, when online classes had become the norm. In a conversation with Prof. Bhas Bapat, who has been the Chairperson of the Coordination Committee of the Department since its inception, we gained insight into how this new department came into being. "This idea has been in my mind for a long time. And during the time I was Dean, Academics, I had a good opportunity to start slowly", recalls Prof. Bapat, adding that a few colleagues showed keen interest in pursuing the idea. The Coordination Committee consists of five other faculty members from IISER Pune (Anirban Hazra, Aparna Deshpande, Joy Monteiro, Pooja Sancheti and Supriya Pisolkar), and there is an Advisory Board consisting of people with a wide range of experience in the field of Science Education (Ashok Rao, Jyotsna Vijapurkar, Kamal Mahendroo, Padma Sarangapani and R Ramanujam).

Reflecting on his role as Chairperson, he highlights, "The field of Science Education in our country, from a formal academic sense, has a minuscule presence compared to other disciplines. There are a few institutions such as the Homi Bhabha Centre for Science Education, Tata Institute of Social Sciences, the College of Education in Delhi University, and a few Regional Institutes of Education for it. Beyond these, there have been many noteworthy non-formal efforts, such as the Hoshangabad Science Teaching Programme. We have a large number of BEd and DEd colleges, but these don't have any research output. In the regular disciplines, the pool from which you can draw faculty from is very large. This, unfortunately, is not the case with Science Education. For a department you need faculty members, you need courses to be run, you need research programmes, and so on. We have been looking for people in India and outside India having demonstrated research in Science Education. Our search continues; finding people has been the biggest challenge. We have a few visiting faculty members at this point, and we've just made an offer for appointment to our first faculty, and we're hoping that he'll join soon. We have kept up the momentum by offering courses in science education and having people come over for talks and so on."

Speaking about the design and structure of the first courses, he says, "Introducing the very idea of science education as a discipline to our undergraduate students is also a challenge. So the courses that we designed had to cater to this. We also had to look at what we were capable of. It had to be a mix of what was feasible, what was pragmatic, and what was needed. Then we had to look at who were the people who would be able to come as visiting faculty members and teach long courses. So after much discussion with advisory committee members and a realistic assessment of our capabilities, we planned our courses." The Cognitive Bases of Science and Science and the World were the first two courses offered by the department in the 2022 August semester. In the next semester, Philosophy of Education, Pedagogy of Science, and Role of Media, Models and Experiments in Science Education were introduced. Three of these were taught by our visiting faculty colleagues: G Nagarjuna, Shamin Padalkar, and K Subramanian. Internally I, Anirban and Joy put our heads together to offer the course "Science and the World". He says, "This was quite a challenge, a pleasant one for sure! However, it needed a lot of effort – we really had to think differently, draw upon our interests and experience, read up a lot, and do a lot of brainstorming to get this course going. We wanted to bring out the connection between people and society on one hand – the prevalent social-political-economic conditions, if you may – with the development of science; the nature of science; the process of science and the impact of science in changing the world."

He thinks the progress of the department has been much slower than what the team had anticipated because of difficulty in getting faculty. However, in terms of student participation, they have actually been quite happy. Typically, the courses get about 30-40 students, some courses get around 15 students. But he believes it is a very healthy number for a new department, in a discipline that is not fashionable. Another encouraging part is that there are students doing their master's project in science education. Although they have not taken up science education for PhD, he thinks that some of them will probably come back into this field. He believes, "As we get more faculty members and we offer more courses and consolidate our position, I think we will have more students pursuing this field."

Because science education is not a known discipline to students at or before the undergraduate stage, most students coming to IISER are geared toward mainstream science. Prof. Bapat explains how these courses can be valuable even in that scenario. "If they want to pursue science as their career, I'm not saying science education as a career, but science as a career, they would still benefit by taking these courses. We have seen from the feedback received from students who have taken our courses that these courses give a completely different perspective on how science happens, which almost never finds place in our regular disciplines. That is something important: becoming aware of the process of science. These courses make them aware of what aspects there are to epistemology – the process of building knowledge – as opposed to merely saying that I have a theory which works, and this is how I'm using it. So I would really encourage everyone who is looking forward to a career in science to join these courses. They do give a completely different perspective."

Typically, the courses are offered in the later years of the degree. On introducing these courses a bit earlier, he says, "Looking at the content of the courses and the different thinking that is needed to appreciate the content of the course and do well, we feel that that comes only with a certain maturity, certain exposure to science research and other aspects. I think there was almost no disagreement about this point among either our own coordination committee or even among advisory board members. The other issue is that the first three semesters of the curriculum are already heavy in terms of number of courses. So finding a place for yet another course is difficult. I think the earliest it can only happen is in the fourth semester, as an elective. We should have a course appropriate for that stage, which will have a flavour of science education, be of general interest, and not be so demanding that students need a certain mastery of science or certain experience in science research. One such possibility is History of Science, but we have not yet come down to offering it because we need to find people who will be able to offer these courses. It may happen in a year or so, and we might have courses earlier on than they are now."

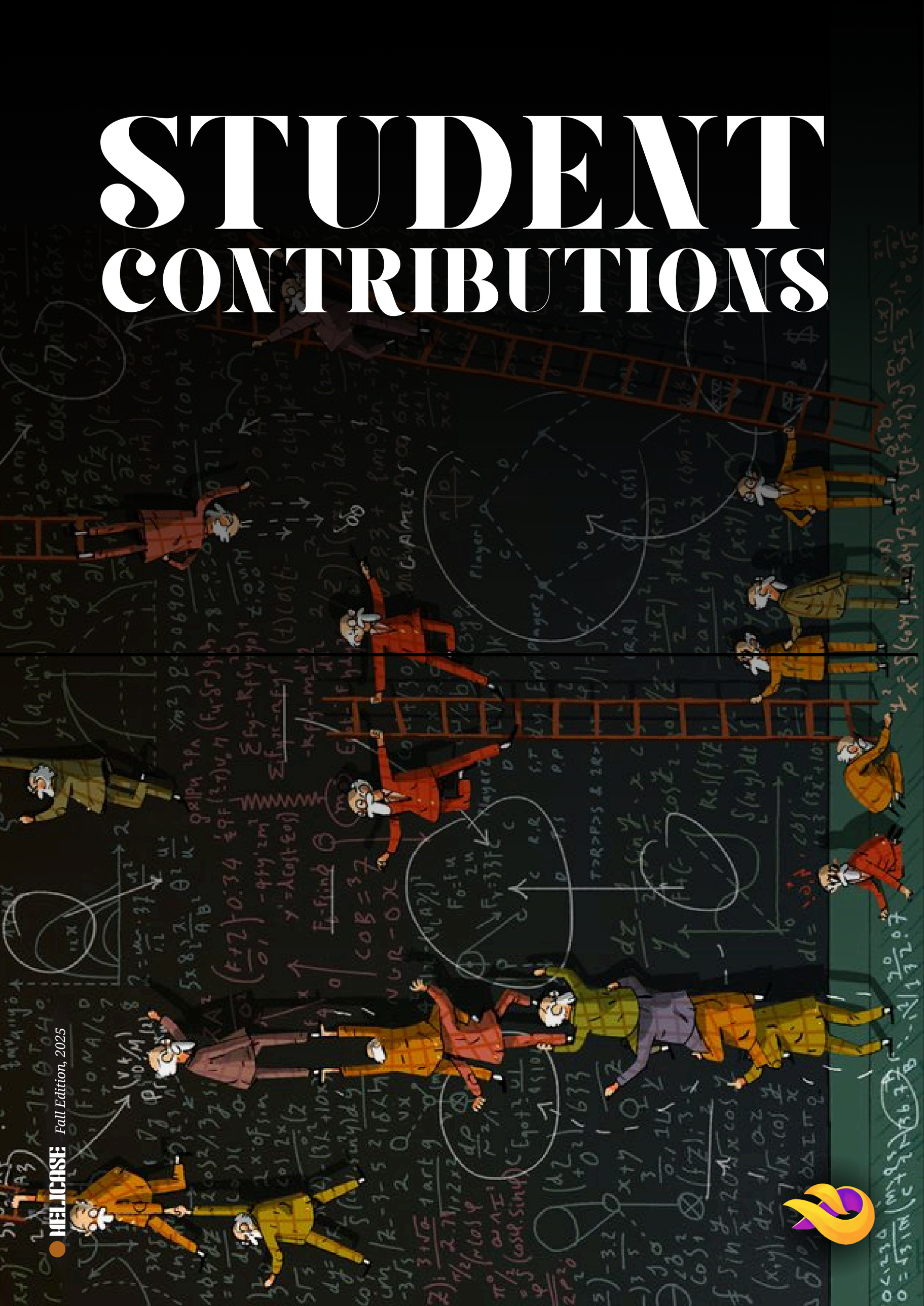
When it comes to career opportunities for students seriously engaging with science education, the landscape is still evolving. "The efforts to improve teacher education are not terribly well organised. There are opportunities in that. If IISER Pune succeeds in having a good department, I'm pretty sure a few other IISERs and IITs will follow. So I'm hoping that five years down the line, we'll have many more academic opportunities in this discipline. One other thing which I would like to advocate based on my personal journey is that if you are doing science, use your skills to help teachers for teaching science at schools. Teachers need this continued help. They need assurance from people who they feel know science better. They have classroom experience, and they know how to handle a class, they know what works, they know what curricula are. But often they get stumped in methods, pedagogy, or even subject matters. And that is when they really look for partnering, collaborating with scientists, with people who are in the field of science so that they can improve their performance, their teaching. So even if you are not in the mainstream science education field, I would suggest to all those who intend to pursue science as a career to devote some of their time to this aspect. If you become a scientist, put in a little bit, say 10% percent of your time, in such things, and that way it will be very rewarding. Opportunities in science education per se are, I'll be honest, are far fewer than what they are in regular science. But you know, it is a different area, and opportunities will come from different directions or may not always be similar to research areas in regular science. They would be very diverse and fewer."

Speaking about how these courses will be helpful in mainstream research, he says, "I think research in the primary discipline will benefit in a relatively indirect manner. When you look at research in any of the standard disciplines, the way it generally gets done is that there are well-defined subtopics, subareas, and hot topics. There are some areas of research which are currently being pursued. There are some questions that are known to the community, and then you start working on that. But there could be another side to this, which is where you look at some foundational aspects of that science. If you are researching such things, then what you learn in some of the science education courses will come handy because these courses actually go to the foundational level of science and are agnostic to which specific subtopic of science you are engaging with. The manner you train yourself to think in these courses will help you if you are really looking to do research in foundational areas of any of the standard disciplines. If you are looking at the possibility of research in science education itself, these courses are sort of small foundations. Courses like the Cognitive Bases of Science or Pedagogy of Science are really at the core of science education, where you worry about how knowledge gets built, which teaching practices are the best, which teaching practices work for certain topics, which teaching practices don't work, etc."

The committee has considered the possibility of offering a major/minor in BS-MS. Prof. Bapat says, "There are three or four directions along which the department is expected to evolve. Offering a minor in science education would be one of the first things we wish to achieve, once we have a few more faculty members. We'll also have research streams, and there are two things that I feel will be pursued. One is the use of technology in education, like modelling how we learn or students learn, and how technology can help with this, the other field would be research in teacher education. How to develop a curriculum for teacher education? What are the things that are needed to prepare a teacher better? Then there is the need for training in-service teachers – those who are already teaching, but need to be trained better to have an update on their skills and so on. A teacher education programme is something that we have in mind in the long run. Over that period of time, we may be able to offer a science education major also. Now, that is a little tricky because now, whether this will be a BS-MS, a separate science education degree, or something else, which will actually line up better with the existing national scenario and norms, remains to be seen."

Prof. Bapat recommends a reflective exercise readers for all BS-MS students. He suggests thinking back to when you were in class 6, 7, or 8, recalling what you believed, how you saw the world, and how you understood science at the time. Then, compare that to what you know now. Notice how your ideas evolved, where there were misconceptions, or where learning felt unclear or uninspiring. Ask yourself how those topics could have been taught differently to make them more engaging or easier to grasp. He also urges you to reflect on things you once accepted without question; have any of those turned out to be inaccurate? Through this exercise, he hopes readers will uncover insights not just about how they learned, but how science could be taught more meaningfully. This will help appreciate the need for research and teaching in the discipline of science education.

STUDENT CONTRIBUTIONS



CINEMATIC CYMATICS

-Rupsa Chatterjee

“Whenever we look in Nature, animate or inanimate, we see widespread evidence of periodic systems.” “ The more closely one examines these functions, the more evident do these recurrent sequences become. Events then, do not take place in a continuous sequence, in a straight line, but are in a continual state of constant vibration, oscillation, undulation and pulsation.”

OOne can do nothing but try to understand nature, and today, we delve into a fascinating example of how art and science intertwine beautifully while exploring how subtle changes affect sounds and waves. We're talking about cymatics, the study of visible sound, a subset of modal vibrational phenomena. Hans Jenny (1904–1972), a physician and natural scientist often called the "father of cymatics," wrote in Cymatics: The Study of Wave Phenomena, "This is not an unregulated chaos; it is a dynamic but ordered pattern."

Cymatics involves vibrating a surface, such as a metal plate or a liquid-filled dish, to make regions of maximum and minimum displacement visible using a thin coating of particles, paste, or liquid. Distinct patterns, like star-shaped designs on a plate or concentric ripples in water, emerge in the medium, depending on its shape and the driving frequency.

Sound is a longitudinal pressure wave that propagates through a medium by compressing and rarefying molecules, traveling parallel to the direction of wave propagation. However, when a transducer, like a speaker, vibrates a circular dish filled with water, the longitudinal sound waves cause mechanical vibrations that displace the liquid's surface, creating transverse surface waves where the water moves perpendicular to the direction of energy transfer. As these waves spread outward and reflect off the dish's boundaries, they form standing waves with nodes (points of minimal movement) and antinodes (points of maximum movement), visible as intricate patterns on the water's surface.

On a Chladni plate, fine particles like sand settle at nodes, regions of minimal vibration, forming geometric patterns, such as diamonds or grids, that reflect the plate's vibrational modes, determined by its shape and the driving frequency. These patterns arise from standing flexural waves, which involve the bending of the plate, not directly from peaks and troughs.
In a liquid medium, such as a dish of water vibrated by a transducer, transverse surface waves form, influenced by the liquid's properties (e.g., thickness, flow resistance, and surface tension) and the dish's shape and size. These factors govern how waves propagate, reflect, and dissipate. When the driving frequency matches the medium's resonant modes—determined by the dish's dimensions and the liquid's properties—standing waves form due to interference between incident and reflected waves. Constructive interference creates antinodes with maximum vertical displacement, while destructive interference forms nodes with minimal movement, producing visually striking patterns. Higher surface tension in liquids creates sharper, more defined patterns, while flow resistance affects how quickly patterns stabilize.

By exciting a medium at specific frequencies, typically using a transducer for liquids or a violin bow for solid plates, we can create captivating patterns. Sweeping through a range of frequencies, while adjusting amplitude, causes the medium to respond with symmetrical geometric patterns at resonant frequencies. These patterns stem from standing transverse waves in liquids or flexural waves in plates, shaped by the interplay of incident and reflected waves at the medium's boundaries.

For Chladni figures, a brass plate sprinkled with sand is vibrated, often by drawing a violin bow along its edge. Depending on the excitation point and frequency, various patterns emerge, corresponding to the plate's resonant modes. Mary D. Waller advanced this work by systematically studying the acoustic and vibrational properties of such plates. As frequencies are swept from low to high, the plate vibrates more intensely at resonant frequencies, producing distinct patterns where sand collects at nodes due to destructive interference, while antinodes experience maximum displacement.

Importantly, these patterns do not directly represent the frequency itself but rather the resonant mode of the medium excited by that frequency. The patterns are a manifestation of the medium's response, shaped by its properties—stiffness and density for plates, or thickness, flow resistance, and surface tension for liquids—and boundary conditions. This distinction corrects a common misconception that each frequency produces a unique pattern independent of the medium. The medium's resonance is critical, as it governs the formation of standing wave patterns.

Cymatics offers a rare glimpse into nature's interconnectivity, where art and science converge. The patterns, whether sand forming intricate designs on a plate or waves rippling in water, are triggered by specific vibrations, frequencies, or even music, revealing the dynamic interplay of matter and energy!

Click Chemistry and Bioorthogonal Chemistry

-Saloni Kumari



Carolyn R. Bertozzi
Stanford University, USA



Morten Meldal
University of Copenhagen, Denmark



K. Barry Sharpless
Scripps Research, USA

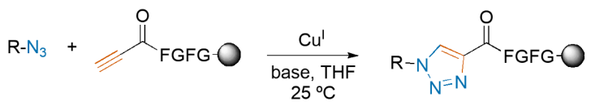
Let's Click Molecules Together... but why? Because it sounds fun? Simple? How is this going to help us anyway? Well! We will know it shortly.

The 2022 Nobel Prize in Chemistry was shared by three successful scientists, **K. Barry Sharpless** , **Morten Meldal**, and **Carolyn R. Bertozzi** , for a straightforward approach to snap two molecules together to form one product. Consider LEGO cubes; you will see a variety of ways to combine these cubes to create a shape. Is this analogy helpful? No? Then, consider two belts (small molecules) joined by a buckle in between, forming one long belt (product). We will see that these buckles can be a copper reagent or a strained ring derived from Cyclooctyne.

But why do we need this? Diverse chemical molecules in nature are difficult to imitate artificially and form by a series of reactions with many intermediates that result in product formation with by-products. All the intermediates and derivatives are used in natural processes, but the same in artificial methods remains unwanted.

$$A \rightarrow B \rightarrow C \rightarrow D \rightarrow E \rightarrow \text{Product} + \text{By-product}$$

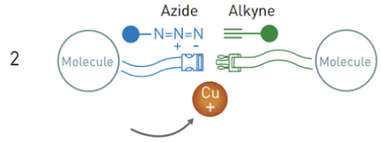
K. Barry Sharpless[1] coined "Click Chemistry" and formulated a way of producing complex molecules without intermediates and by-products. Imitation of natural complex molecules became easy, inexpensive, and efficient. The crown jewel of Click chemistry—**Copper-catalyzed Azide-Alkyne Cycloaddition**[2]—was presented by Mortan Meldal. This reaction concluded that any two molecules consisting of an Azide and Alkyne functional group can be snapped together to form a Triazole, a versatile chemical that is one of the ingredients of dyes, antibiotics, fungicides, etc.

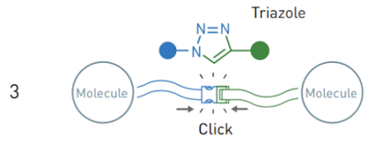


Carolyn R. Bertozzi gave an entirely new dimension to **Click Chemistry** and pioneered the concept of Bioorthogonal Chemistry (reactions that occur without interfering with the chemistry of biological systems.). In her Nobel speech, she compares Bioorthogonal Chemistry and Biological systems with two galaxies of a chemical universe that neither interact nor interfere with each other. On her long journey in Bioorthogonal Chemistry, her work was inspired by scientists like Staudinger, Huigsen, etc. but was limited due to the slow reaction rate. Eventually, she read about Copper-Catalyzed Azide-Alkyne Cycloaddition by Mortan Meldal (one of her co-laureates). However, still, it could not solve the problem related to Bioorthogonal Chemistry because copper ligand as a catalyst is too toxic for a biological system.

Finally, she and her colleagues used the concept that a strained ring determines the reactivity of the functional group; the pi system in the strained ring reacts and releases the strain energy that accelerates the reaction. A scientific paper in 1961 by **Prof. Dr. Georg Wittig**[3] revealed that cyclooctyne was the smallest stable Cycloalkyne, and a German statement in his writing meant- The reaction proceeded like an explosion to form corresponding Triazole. Therefore, they introduced Azide-Alkyne Cycloaddition with a strained ring system. This method was called Copper-Free Click Chemistry,[4] and her colleagues discovered many Cyclooctyne-based probes to be used in Biological systems. The structure and reactivity correlation (Classic Organic Chemistry) resulted in many Cyclooctyne-derived probes that could be tuned in reaction kinetics over several orders of magnitudes. DIFO (Difluorocyclooctyne) is the first and most widely used modified sugar for imaging.







Finally, her two colleagues— **Jeremy Baskins and Scott Laughlin** — used Zebrafish as a model organism for its translucent body, apt for fluorescence imaging studies. It led to the production of the first fluorescent zebra fish of different color showing different proteins at various stages of development. Glycan (cell surface sugar) imaging was the first and the most significant breakthrough in the arena of bioorthogonal chemistry. It builds up and concentrates at the junction during cell division. It gave a new way of imaging cell division by probing Glycans.

On the other hand, she designed clickable antibodies (antibodies specific to tumor cells clicked with the enzyme). Tumor cells are recognized to have large amounts of glycan on their surface to avoid its detection by the immune system. These clickable antibodies bind to tumor cells, and the enzyme degrades the glycan present on the surface of the cell. These antibodies are expected to provide excellent results in the most complex reaction vessel, "The Human Body," therefore undergoing clinical trials.

Bioorthogonal Chemistry not only provides the cure but also finds the cause of the disease and eliminates it from its root. It explains why and how the biochemical processes occur in our body and how drug delivery occurs in the body. It is making a significant impact in the pharmaceutical industry where Azide acts as a chemical reporter to probe biomolecules. Azide treatment shows several noxious effects on the cells, therefore, we must expand the toolkit (buckles) and its application, which is still a matter of significant research that needs to be worked upon.

DOES Quantum Mechanics Matter?

The POV of a Condensed Matter Physicist

-Anargha Mondal



Michael Ellis Fisher
English physicist, chemist and mathematician

Reductionism is the philosophy of explaining more complex phenomenawith the aid of simpler or more elegant phenomena. According to the famous high- energy physicist Dr. Franck Wilczek, "***Its [reductionism] form belies its content. Explaining things is augmentation, not reduction. I much prefer Newton's phrase, Analysis and Synthesis, to describe the process of breaking problems or phenomena into simpler component parts (Analysis), and then building up from those parts (Synthesis)***". During the previous decades, the reductionist program had been profoundly successful, with the discovery of the electron, neutron, and proton; the theoretical predictions of the neutrino and the meson; the pion in cosmic rays; and many more.



Yet, with the birth of solid state physics around 1940, the initial focus on one-electron properties of metals and semiconductors turned in the 1950s to the collective properties of matter through many-body theory. In due course, the field became known as condensed matter physics, reflecting the increasing focus on all matter, not just solids, and especially on collective phenomena.

In 1988, the famous condensed matter physicist, **Michael E. Fisher**, authored what must surely be a candidate for his least cited paper. Entitled "**Condensed Matter Physics: Does Quantum Mechanics Matter?**", it poses an outrageous question. Fisher aimed to review the state of condensed matter physics as it stood on the 100th anniversary of the birth of Niels Bohr, with a special remit to comment on the overlap with Bohr's ideas on the fundamentals of quantum mechanics. The last decade had seen five major discoveries in condensed matter physics, ultimately garnering 5 Nobel Prizes, and each a splendid manifestation of quantum mechanics. Nevertheless, Fisher evidently did not regard his role as to provide a self-congratulatory pat on the back to condensed matter physics. Instead, he took it upon himself to explain his thoughts on "*... what condensed matter physics does, or should be doing, and what defines condensed matter physics, and thence to approach the question 'Does quantum mechanics matter?'*".

The viewpoint that he expounded was at the time still rather unorthodox in many areas of physics and science, in particular his perspective that "the question of connecting the models with fundamental principles is not a very relevant issue or central enterprise." This would come as news to those in the physics community engaged in the reductionist program, including, to some extent, condensed matter physicists but to a far greater extent, those working in high-energy physics. It quickly became clear that ***novel macroscopic phenomena transcended the additive properties of single degrees of freedom***, and a renewed focus on collective properties was seen by many as the defining aspect of condensed matter physics. Indeed, Fisher is very clear where he stands on this point: "*The basic problem which underlies the subject is to understand the many, varied manifestations of ordinary matter in its condensed states and to elucidate the ways in which the properties of the 'units' affect the overall, many-variable systems*". Again, he is very explicit about the questions that animate the task of addressing the basic problem underlying condensed matter physics: "*What are the states of matter? ... What is their nature? ... How do the various states transform into one another?*" As we will see, inextricably linked with these questions are two concepts that are subtle and took a long time to be appreciated: the notions of "***minimal models***" and different "***levels of description***".

Fischer's article, and the novel approaches he addressed there, was a masterly contribution that both recalled the extraordinary collision between physics and philosophy of a previous age, and heralded the dawn of a new era. The new approaches prescribed by Fischer can and have proven to be especially important for complex systems such as biology and turbulent fluid mechanics. Systems in such fields are more complex than those dealt with by physicists. In biology, there are many more levels of description than in physical systems, because of the intertwining of molecular sequence, three-dimensional structure, large-scale molecular motions, elasticity, gene expression, metabolism and energy flow, regulation, signaling, cell division, tissue mechanics, electrical activity, ..., all the way up to ecology and evolutionary processes.

Even elementary particle physicists came to the clear realization that ***their subject was about effective field theory, and not about fundamental physical law*** and within a few years of Fisher's article, this view was superseded by the general acceptance of ***effective field theory***. The famous **Howard Georgi** describes this change in perspective in a remarkable comment that sounds the death nell for the fundamental viewpoint of elementary particle physics: "*How does this process end? It is possible, I suppose, that at some very large energy scale ... the theory is simply renormalizable in the old sense. This seems unlikely ... It may even be possible that there is no end, simply more and more scales as one goes to higher and higher energy. Who knows? Who cares?*"

So, **is quantum mechanics truly an outdated tool for particle physcists? Maybe. But it is utterly clear that a reductionist approach to this discipline has been exhausted and it needs a change of perspective to move forward.**

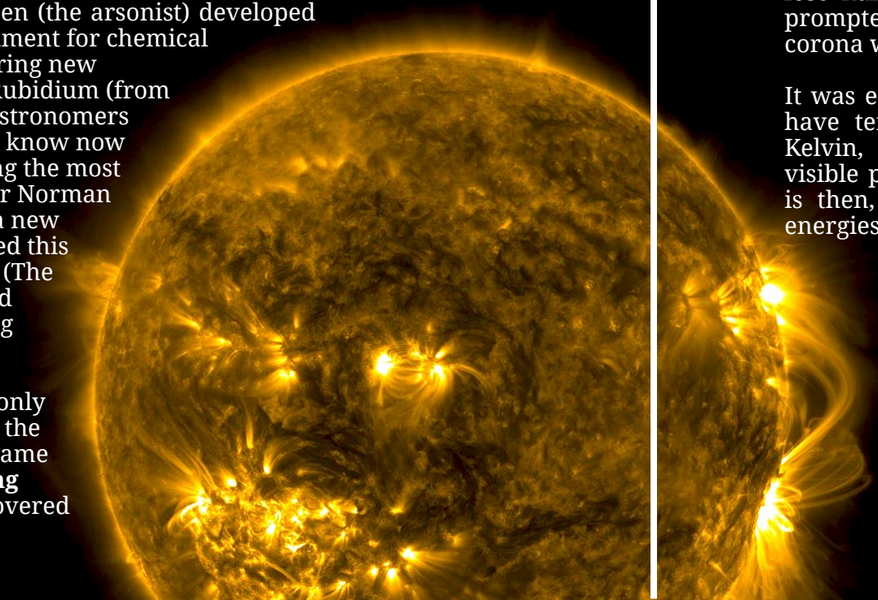
CORONIUM

The Element That Wasn't

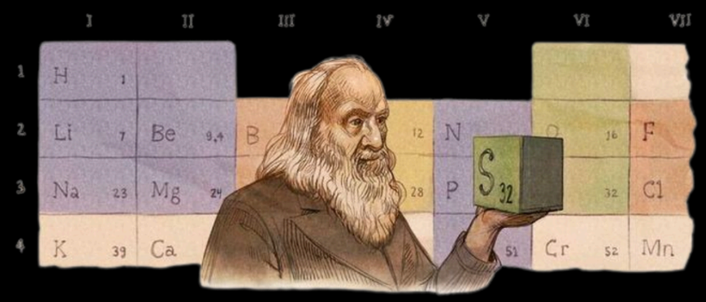
~ Soumya Ranjan Nayak

Let's talk about a different kind of Corona for a change, shall we? This particular sequence of "corona" related incidents happens in the 19th century, and operates in a domain wholly unrelated to the medical one.

Kirchoff (of Kirchoff's law(s) fame) and Bunsen (the arsonist) developed the spectroscope in 1859. They used the instrument for chemical analysis, eventually resulting in them discovering new elements Caesium (from mineral water) and Rubidium (from a mineral called "lepidolite"). Contemporary astronomers immediately realised the potential of what we know now as spectroscopic analysis, and started analysing the most prominent source of light we have, the Sun. Sir Norman Lockyer, the first person to do so, discovered a new element in the "solar spectrum", and christened this element Helium, after the Roman deity Helios (The relative rarity of this element on earth ensured that this element was detected on earth 25 long years later!)



The corona was the outermost 'ring' that was only visible during total solar eclipses. Scientists of the time believed that its spectrum would be the same as regular sunlight's, so it was **groundbreaking** when two scientists Young and Harkness discovered



a particularly strong new emission line in the coronal spectrum, during the eclipse of 7 August 1869. The wavelength of the spectral line was decided to be 5303 angstroms, which did not correspond to any known element. The community by consensus believed that a new element akin to Lockyer's Helium had been discovered.

This new element was christened CORONIUM, in the footsteps of its predecessor- Helium. Many other unexplainable lines were subsequently discovered and people attributed most of them to some "excited states" of coronium.

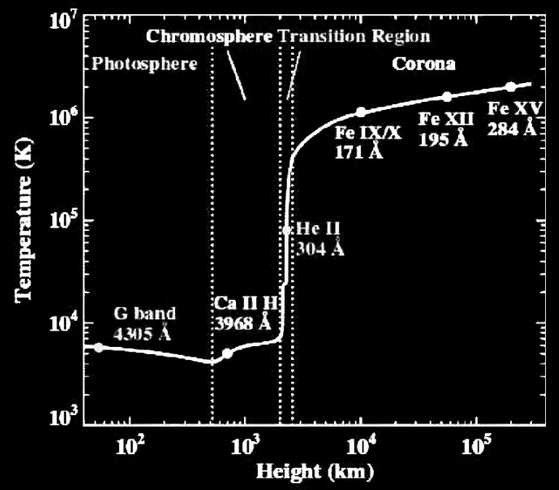
In the 19th century, a certain generously-bearded Russian chemist was gaining universal acclaim, hell-bent on trying to unify all of chemistry based on periodic properties of elements.

Mendeleev's table had spaces which he boldly predicted would be filled by elements that had not yet been discovered, and this was proven to be correct after the discovery of eka-silicon (now germanium), eka-tantalum (now protactinium) etc. He heard about our hypothesised mystery element, and tried to fit it AND ether into his periodic table, by claiming that they were lighter than hydrogen elements. This was not an unprecedented extrapolation, because his periodic law *seemed* to work just fine as the mass number went up, it would not be far-fetched to believe that there could be undiscovered elements in the opposite direction with the low mass explaining their undetectability /unavailability on earth.

To be completely fair to the Russian with ambition, the lack of knowledge of the not-yet-discovered protons, and the idea of periodicity being a function of atomic number held him and many other prominent scientists back. The theory of ether was torn down after growing evidence of absence, and a crazy haired genius shot into fame, building on this disintegration of paradigms.

What became of our beloved speculated "element" then?

Edlen and Grotrian, in the 1930s, found that this line corresponded to Fe XIV (Iron's +13 oxidation state), and this possibility went unnoticed since the ionisation state had not been observed experimentally. But how can a regular Fe atom lose half of its electrons? Questions like these prompted the fascinating conclusion that the corona was HOT.



It was estimated that the corona would have to have temperatures in the order of a million Kelvin, about 150-450 times hotter than the visible photosphere for this state to exist. What is then, the reason for these extremitudes of energies and temperatures?

This is, surprisingly, a yet-to-be-solved problem in astrophysics. Some mechanisms explaining this coronal heating have been put forth, and more data is being taken by space agencies around the world (including our own, with the 2023 ADITYA L-1 mission).

Jumping to quick conclusions led to a myth that was tried to be explained by an inherently flawed framework. Sometimes, baffling scenarios have to be looked upon from entirely different viewpoints for them to make sense. Sometimes, theorising has to let technology catch its breath and, sometimes, things are just much hotter than they appear to seem.

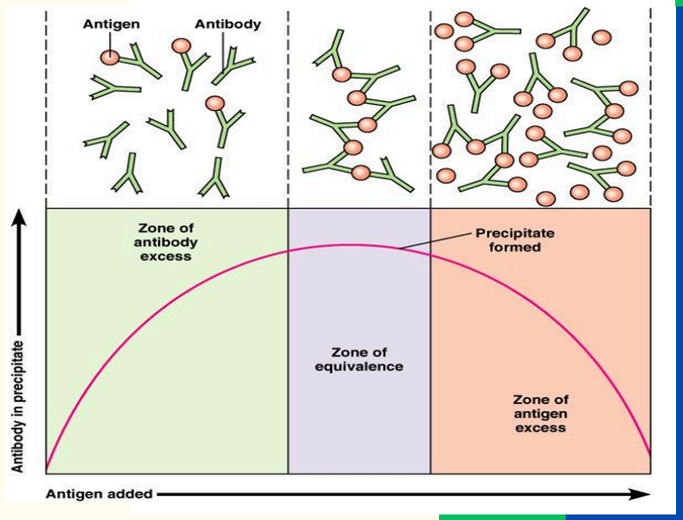


DECIPHERING THE STRUCTURE OF ANTIBODY

~Gurjot Singh Sawhney

Throughout the nineteenth century, various attempts were made to solve the structure of antibody. For a start, it had been established that anti body as a whole molecule was not required for combining with antigens. In 1941, Petermann and Pappenheimer through their studies on horse antidiptheria toxin(which was purified using pepsin enzyme) showed that they can obtain a product that still has the ability to combine with antigen but with substantially less molecular weight, roughly 113,000 daltons. At the same time, Landsteiner showed that small weight molecular peptides from the acid digest of silk could inhibit precipitation reaction of soluble silk fibroin.

In these studies, fibroin pro tein present in the silk was allowed to react with its corresponding antisera which was prepared by injecting small amounts of purified and dissolved silk proteins in rabbits. Later, the immune sera (or antisera) was harvested which contained the antibodies against silk fibroins. Generally, in any antibody-antigen reaction, the precipitation can be inhibited by the addition of antigen or antibody in excess(known as the zone of antigen excess and the zone of antibody excess respectively). However, there is a maximum amount of precipitation observed when both antibody and antigen are added in optimal amount. This is known as the zone of equivalence.



Precipitation can also be inhibited by addition of an active antigenic part of molecule. In Landsteiner's experiments, the small peptides from the acid digest of silk acted as active antigens and hence inhibited the reaction between the antigenic fibroin and its corresponding antibodies in the immune sera. Land steiner's experiments and various other experiments suggested that antigenic sites on the antibody molecule were very small. Later on, researchers made various attempts to find active fragments of antibodies which can still bind to the antigen. This was achieved with help of papain enzyme. However, there was a substantial reduction in the size of fragments and this time to roughly 40,000 daltons. On elution of papain digest of antibodies, researchers found three fractions-fraction I, fraction II and fraction III. Two of these fractions(fraction I and II) retained the ability bind with the antigen and were hence named Fab fragments(fragments for antigen binding). Fraction III due of its ability to crystallize was named Fc fragment(fragment crystallizable region).

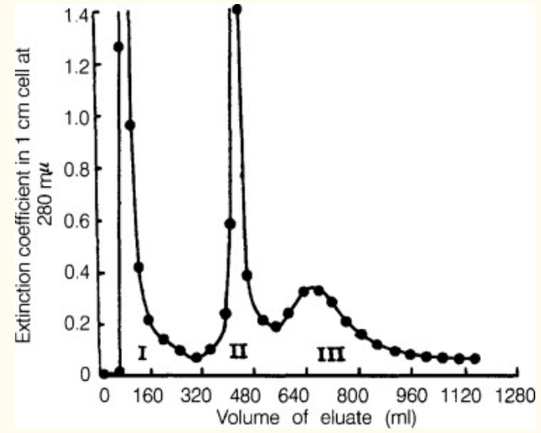


Figure 1: Results from elution of papain digest- the similar peaks in the fraction I and II are indicative of their similar nature. In fact, Nisonoff and colleagues later showed that they are very similar chemically and antigenically.

Nisonoff later found active fragments in the peptic digest of rabbit immunoglobulin. These fragments are called as F(ab')2 fragments. The papain digest studies of γ globulins established that their structure was made of these three globular proteins(Fab and Fc fragments) which were thought to be tightly folded as they resisted further degradation by papain

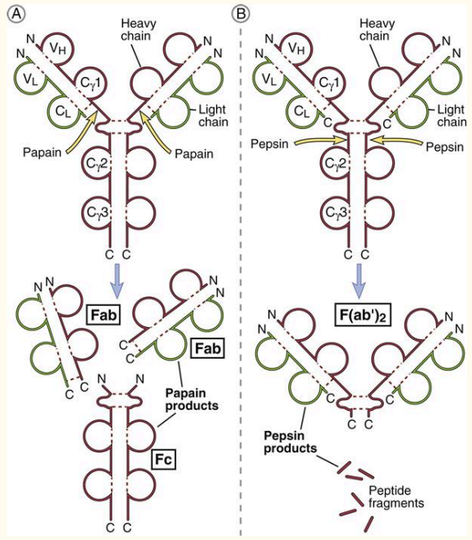


Figure 2: Cleavage of rabbit immunoglobulins by papain and pepsin enzymes shows distinctively different results

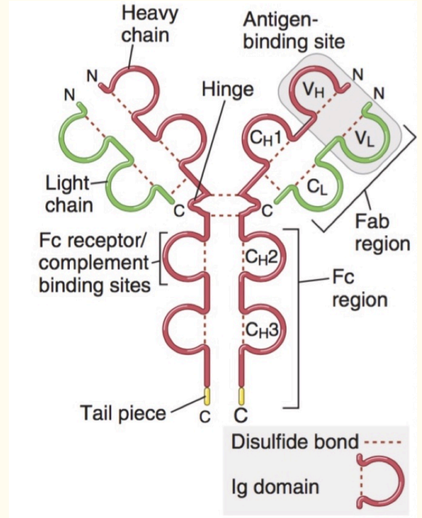


Figure 3: Four peptide chain structure of a typical immunoglobulin(IgG for reference)

An attempt was made to link the peptide structure of antibody to that of a single chain though it remained unsuccessful. It was later confirmed from double diffusion studies that antibodies are multichain structures. There are four peptide chains-two heavy and two light chains connected by disulphide bonds. Using reduction methods the researchers were able to break the inter chain disulphide bonds and they could be separated into heavy and light chains by running them on sephadex columns(a way of separating different peptide chains based on their molecular weight). The double diffusion studies confirmed that the light chains are present only on the Fab region while heavy chains are present on both Fab and Fc region. These developments helped to propose the four peptide chain model of antibodies as we know today.

TRUST BROKEN? I SEE A PATTERN HERE!

~Jagadish Parameswaran

what is it a-chord-ing to you?

Let's say you are giving an exam based on logical reasoning, and you are asked to find the next number in the following sequence: 1 2 4 8 16 What would your answer be? 32, right? You may get the answer marked right and be proud of your pattern recognition skills, but mathematics isn't that kind! Take a circle, choose n points on it's circumference, and connect all the points using chords such that no three chords are concurrent. For $n = 1$, there is no chord, and therefore the circle just exists as one whole. For $n = 2$, we get one chord and therefore, two segments of the circle. For $n = 3$, we get four segments due to three chords. For $n = 4$, yes, your intuition is perfect! We break the circle into eight segments. Continuing this trend, we find for $n = 5$, we get sixteen segments and for $n = 6$, 32 segments. Right? Wrong! It might seem astonishing, but for $n=6$, we end up with 31 segments of the circle rather than the expected 32. This example in geometry might have already caused some annoyance and triggered your OCD, but this is just the beginning!

Is this too basic for you?

There seems to be a pattern when we write prime numbers(which are in base 10) in base 4. It seems as if the numbers written in base 4 are also prime numbers in base 10. We might think that this is something that holds, just because it's beautiful. Guess what, this is false. The pattern breaks at 31, which written in base 4, is $133=19\times7$.

Base 10	Base 4
2	2
3	3
5	11
7	13
11	23
13	31
17	101
19	103

Computer Chains

$$\sum_{n=1}^{\infty} \frac{\lfloor n \cdot e^{\pi\sqrt{163}/3} \rfloor}{2^n} = 1280640$$

A perfect integer? Almost! Such details often go unnoticed as most moderately powerful computers cannot handle such a small error. We might want to believe what is most beautiful and appealing, but one must curb this urge and sought to the analytical method.

Devious Divsor

Here's another example! The GCD of $\{n^{17} + 9, (n + 1)^{17} + 9\}$ always seems to be 1. You may start writing a program in your computer to check this and you would end up agreeing with the statement. You might also want to start using this as a co-prime numbers generator! However, the statement is false. You wouldn't find it out as the first counter example is when
$n = 842443292559288932928819732230890067245942046079243$, which is absurdly huge!

Sines of Broken Trust

The following pattern breaking absolutely breaks my heart as well.

$$\int_0^\infty \frac{\sin(x)}{x}\,dx = \frac{\pi}{2}$$

$$\int_0^\infty \frac{\sin(x)}{x}\cdot\frac{\sin(x/3)}{x/3}\,dx = \frac{\pi}{2}$$

$$\int_0^\infty \frac{\sin(x)}{x}\,\frac{\sin(x/3)}{x/3}\,\frac{\sin(x/5)}{x/5}\,dx = \frac{\pi}{2}$$

$$\int_0^\infty \frac{\sin(x)}{x}\,\frac{\sin(x/3)}{x/3}\cdots\frac{\sin(x/13)}{x/13}\,dx = \frac{\pi}{2}$$

$$\int_0^\infty \frac{\sin(x)}{x}\,\frac{\sin(x/3)}{x/3}\cdots\frac{\sin(x/15)}{x/15}\,dx = \frac{467807924713440738696537864469}{935615849440640907310521750000}\pi$$

$$= \frac{\pi}{2} - \frac{6879714958723010531}{935615849440640907310521750000}\pi$$

$$\approx \frac{\pi}{2} - 231\times10^{-11}$$

The beauty of the sequence upto sin(x/13) and the satisfaction we get from it is enough for us to conclude that it holds for all odd numbers. But alas, it breaks. That too by such a small difference!

Sinc-ing in the Pit of Sorrow

The sinc(x) function in math is just a shorthand for sin(x)/x. The following sequence holds upto an even larger number than the previous example. $N = 40248$. But for values of $N > 40248$, the LHS > RHS. Sum-thing's suspicious, isn't it!

$$\frac{1}{2} + \sum_{m=1}^{\infty}\prod_{k=0}^{N}\operatorname{sinc}\left[\frac{m}{2k+1}\right] = \int_0^\infty \prod_{k=0}^{N}\operatorname{sinc}\left[\frac{x}{2k+1}\right]dx$$

It's just a Conjecture, guys!

The Pólya conjecture states that for any $n > 1$, if the natural numbers less than or equal to n (excluding 0) are partitioned into those with an odd number of prime factors and those with an even number of prime factors, then the former set has at least as many members as the latter set. As an example, let's take the number 8. So the numbers in consideration are 1, 2, 3, 4, 5, 6 and 7. Out of these, 2, 3, 5 and 7 have an odd number of prime factors (the number itself). The rest (1, 4 and 6) have an even number of prime factors. The set of numbers with odd number of prime factors, in this case, has more elements than that which has even number of prime factors. It might seem very plausible for this to hold, but without a proof, nothing can be believed. Well, by now your "powerful faith" in patterns would've been destroyed and you would guess for there to exist a counter example, and there sure is one! The number 906150257 is the first counter example.

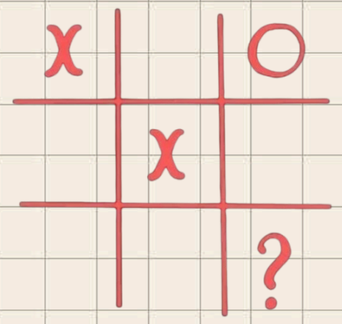
Now you might ask me, "What's the point of all this?". My intention is not to stop your creative pattern recognizing minds from working. It is an essential skill for humans. However, just like any other skill in life, moderation and caution are required. One way to avoid such pitfalls is to get used to the art of writing concise and mathematically sound proofs, which is by no means easy.

As a concluding example, take the polynomial $P(n) = n^2 + n + 41$. Your task is to prove that $P(n)$ is a prime number for all whole numbers n. You might want to start plugging in a few small numbers to convince yourself that it actually works, and then get to proving it! However, it won't be too long before you realize that $n= 40$ and $n= 41$ are clear counter-examples! Trust broken? Definitely!

GAME THEORY & NASH EQUILIBRIUM

~Riddhiman Biswas

Let's start with a familiar game – Tic-Tac-Toe. To understand why we all are familiar with some of the concepts of game theory unconsciously, we would analyse the following situation.



In this situation, the best way 'O' can respond is to tick in the question marked box. Why? This is because in the given situation, 'O' is faced with two options- either try to prevent 'X' from winning (tick the question box) or accept defeat (tick any other box). Thus, given this situation, this is the best strategy 'O' can choose.

This is basically what we would expound upon, the choosing of the best strategy. The above game can be continued, but the thought process is important. Let's first introduce some terms. Later, we will examine examples to get a feel of them.

Game theory is the study of mathematical models of strategic interactions among rational agents. We say rational because often, in real life, people don't play the best optimal strategy. John von Neumann's paper 'On the Theory of Games of Strategy' in 1928, introduced it as a separate field. A non-cooperative game is where the players compete against each other and there are no alliances. We assume that,

1. Each player remembers their decisions.
2. Each player has complete information about strategies that can be taken.
3. Each player is rational.
4. Each player considers only their interests.
5. They all have the same understanding of the game.

In such games, a Nash equilibrium is when no players can gain anything by changing only their own strategy (others' strategies remain the same).

We will understand what Nash equilibrium is by constructing what is called a payoff matrix in the following example.

P1/P2	A	B
A	2,2	3,1
B	1,3	1,1

Suppose there are two players: P1, and P2. The strategies of each of them are A and B, with the numbers indicating the points. The vertical A and B's are P1's strategies, and the horizontal ones are P2's. Each box denotes the strategy combination of P1 and P2. In any box, the first number denotes the points of P1, and the second number is that of P2. Let's analyse this.

Suppose, P2 chooses A. There are two strategies which P1 can take- A or B. P1 will choose the best strategy for oneself irrespective of what happens to P2. What is the best strategy for P1? Strategy A! Why? Suppose P1 chooses B (P2 has chosen A). Then, from the payoff matrix, we see the pointboard is 1,3 (P1 gets 1 point, P2 gets 3 points). But if P1 chooses A (keep in mind P2 has chosen A), P1 gets 2 points (the first number of 2,2) which is more advantageous. Here, each player is concerned only with their gain irrespective of what happens to the other player. Thus,

If P2 chooses A, P1 chooses A. (A, A)
If P2 chooses B, P1 chooses A. (A, B) (keep in track of order!) If P1 chooses A, P2 chooses A. (A, A) (the second number is P2's point!) If P1 chooses B, P2 chooses A. (B, A)

The common strategy is (A, A), as seen from the above analysis. This is the Nash equilibrium.

Let's try a little more complicated one. (Try it on your own, forming statements like the above)

P1/P2	A	B
A	6,6	6,8
B	8,3	4,4

If P2 chooses A, P1 chooses B. (B, A)
If P2 chooses B, P1 chooses A. (A, B)
If P1 chooses A, P2 chooses B. (A, B)
If P1 chooses B, P2 chooses A or B. (B, A) or (B, B)

So, there can be more than one Nash equilibrium (here it's (A, B), (B, A))

Another problem:

P1/P2	A	B
A	6,6	6,5
B	8,3	4,4

As you solved, there is, in fact, no Nash equilibrium here.

In all these cases, what we have implicitly assumed is that we are playing pure strategies, that is we can't use a combination of strategies A and B. For a large number of similar games, we can use a certain combination of A and B instead of sticking to just one. This is called mixed Nash equilibrium.

Let's consider a famous example – the Hawk-Dove game.

Doing similar analyses as above, we see (Hawk, Dove) and (Dove, Hawk) are Nash equilibrium for pure strategies. Suppose P1 chooses Hawk strategy with probability p and Dove strategy rest of the time (with probability $1 - p$). P2 chooses Hawk strategy with probability q and Dove strategy rest of the time (with probability $1 - q$). Then, points scored by P1 when P2 chooses,

P1/P2	Hawk	Dove
Hawk	-1,-1	2,0
Dove	0,2	1,1

...Hawk is $-1 \cdot p + 0 \cdot (1 - p)$
...Dove is $2 \cdot p + 1 \cdot (1 - p)$
We equate these two equations to get $p = 0.5$
Then, points scored by P2 when P1 chooses,
...Hawk is $-1 \cdot q + 0 \cdot (1 - q)$
...Dove is $2 \cdot q + 1 \cdot (1 - q)$
Similarly, $q = 0.5$
Thus, the equilibrium strategy here would be
P1 plays Hawk 50%, Dove 50%
P2 plays Hawk 50%, Dove 50%
The result isn't interesting, but for different payoffs, it may be different.

This, however, is also what is called an evolutionary stable strategy (ESS), which, when fixed in a population, natural selection will alone prevent alternative strategies from replacing it. However, it is not the same as Nash equilibrium even though, in this case, it is. It has a stricter criterion than Nash equilibrium, meaning all ESS are Nash equilibrium, but not all Nash equilibriums are ESS. We won't go into what an ESS is in this article.

Game theory, originally developed for economics, has widespread application in psychology, evolutionary biology, war, politics, and business. The last example borders on evolutionary biology, where an ESS is important in understanding animal interactions, first applied by John Maynard Smith. You can check his book 'Evolution and the Theory of Games' for more on ESS.

HANS SELYE AND HIS NOT-SO MERRY MICE

~Suhani Bhattacharyya

If you are reading this article, it is likely that you are intimately familiar with stress. Whether it is studying for entrance exams, filling out application forms or meeting the deadline to write an article for your university's science magazine, stress has become a normal part of all our lives. As defined today by WHO, it is a state of worry or mental tension caused by a difficult situation that prompts us to address challenges and threats in our lives. But have you ever wondered how the mainstream research into stress began?

In 1932, Hans Selye, a Canadian scientist, during his fellowship at McGill University, was placed in charge of identifying unknown female sex hormones. For this, he decided to take ovarian extracts from cows and inject them into mice to see the effects of excess hormones in the mice. Unfortunately for the mice, his experimental techniques of injecting the hormones and handling the animals could have used more care. Fortunately for us, this led to him discovering unexpected results from the autopsies of their bodies including enlargement of adrenal glands, degradation of the thymus and formation of peptic ulcers in the stomach and duodenum. This could not have been due to the hormones themselves, since they were all different and the effects seen should have been varying. So, instead of improving his methodology to handle the mice, Selye decided to expose the mice to even harsher and torturous experiments including extreme cold and treadmill running. He found the same results in the autopsies of these mice too.

Stress as a concept had been introduced by scientists earlier, but it was Selye who linked the exposure to stressful conditions and resulting physiological changes with the concepts of homeostasis and endocrine hormones in the body.

He introduced the term "General Adaptation Syndrome" which described the three stages of a stress response cycle and used it to represent the "nonspecific response of the body to any demand". His experiments of exposing the mice to prolonged stress (from the moment they entered his lab, till the moment they died, mostly due to stress) meant he was able to differentiate between acute and chronic stress. Acute stress is momentary stress, something everyone is exposed to simply by being a living organism in a world with preys and predators. Chronic or prolonged stress, on the other hand, leads to the physiological symptoms as described from the mice autopsies and causes general illness symptoms such as fatigue. Although these general symptoms are seen in cycles of acute stress, high levels of stress hormones maintained in the body over long periods of time can make our body resistant to the hormones, subsequently leading to a constant state of lethargy and exhaustion.

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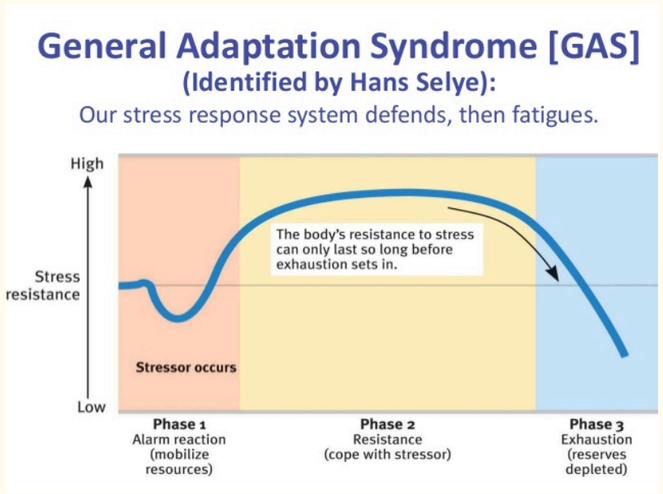


Thus, it was finding the connection between the physiological and psychological symptoms of stress that led to the popularisation of research into it and a Nobel prize nomination for Selye (to the joy of mice everywhere, he did not win). Today, the threat of chronic stress is stronger than ever due to less chances of temporary stress (trying to outrun a lion if it wants to eat you) and more chances of being continually stressed (capitalism). Mental health has come to the forefront as an important issue to be dealt with, but the services need to continue improving. Let's honour the unwilling sacrifices of Selye's mice and try to take care of ourselves.



IF YOU CAN NOT UTILISE IT, CRYSTALLISE IT

All you need to know about time crystals

~Rupsa Chatterjee

A crystal, a debate on free will, the dream of an unwired society, and humanity's obsession with time—all converge in the enigmatic concept of a time crystal, metaphorically. Unlike traditional crystals, which display repeating patterns in space, time crystals exhibit periodic behavior in time, oscillating in specific patterns without external energy input. Proposed by Frank Wilczek in 2012, time crystals break continuous time translational symmetry (CTTS), meaning their physical properties change periodically in their quantum-mechanical ground state, defying the expectation that systems at their lowest energy should be static.

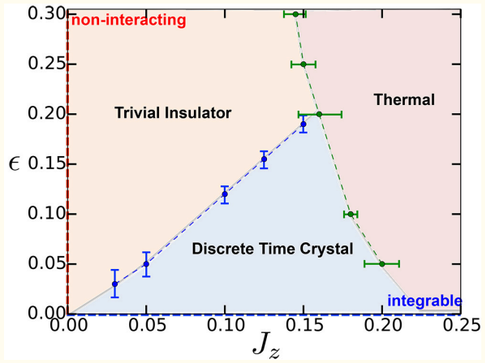
Time translational symmetry implies that the laws of physics remain unchanged regardless of when an experiment is performed. This symmetry is tied to energy conservation via Noether's theorem: if a system's behavior is invariant under time shifts, its energy is conserved. A time crystal challenges this by exhibiting persistent oscillations in its ground state without absorbing or dissipating energy, a phenomenon that initially raised eyebrows due to its resemblance to a perpetual motion machine—a concept forbidden by the laws of thermodynamics.

To visualize this, picture a group of atoms in a preferred configuration, like students in a classroom with assigned seats. A "teacher" (an external force) temporarily disrupts this arrangement, but the atoms return to their original state periodically, without any net energy input. This rhythmic dance in time is the essence of a time crystal.

Wilczek's original proposal suggested a system in its ground state could exhibit continuous time-crystal behavior. However, subsequent analyses, notably by Watanabe and Oshikawa in 2015, showed that such continuous time crystals were impossible in equilibrium systems due to thermodynamic constraints. The ground state of Wilczek's system couldn't sustain perpetual motion without external driving, as it would violate the second law of thermodynamics.

This led to the development of discrete time crystals (DTCs), a more feasible realization. In 2016, Yao et al. proposed a system of interacting spins, such as a chain of ions, where spins align due to magnetic interactions. By periodically driving the system out of equilibrium with an external field (e.g., a laser inducing spin flips), the spins could oscillate at a frequency that is a subharmonic of the driving frequency—a hallmark of discrete time-crystal behavior. Crucially, these oscillations are robust against small perturbations in the driving signal, and the frequency is "locked" to a rational multiple (e.g., half or a third) of the driving frequency. This robustness stems from the system's interactions and symmetry-breaking properties, not from any violation of thermodynamics, as the system is driven and not in equilibrium.

The phase diagram proposed by Yao et al. maps the conditions for DTCs, with axes representing the strength of spin interactions and the imperfection in the periodic driving signal. Within certain regions, the system exhibits stable, time-crystalline behavior, returning to the same state at fixed intervals.



In 2017, two landmark experiments brought discrete time crystals to life. Chris Monroe's team at the University of Maryland used a chain of 10 ytterbium ions, driven by a laser, to observe oscillations at twice the driving period. Simultaneously, Mikhail Lukin's team at Harvard used microwaves to drive nitrogen-vacancy centers in a diamond, observing oscillations at three times the driving frequency. Both experiments confirmed the phase diagram's predictions, showing that the systems exhibited discrete time translational symmetry breaking returning to their initial state after a fixed period, even under slight variations in the driving signal.

In 2021, a collaboration involving Google, Stanford, and Princeton used Google's Sycamore quantum computer to create a DTC in a many-body quantum system. This experiment demonstrated a robust time crystal by carefully tuning interactions and driving parameters, achieving oscillations that persisted for thousands of cycles. While this was a significant milestone, it didn't challenge the laws of thermodynamics, as the system was actively driven by external fields and operated far from equilibrium.

But why the excitement you may ask?
Time crystals aren't just a theoretical curiosity, they hold potential for transformative applications. In quantum computing, their robust periodic behavior could serve as a natural clock or memory element, maintaining coherence in quantum states over time. Coupling multiple time crystals could enable novel quantum information processing protocols, enhancing the stability and scalability of quantum computers.

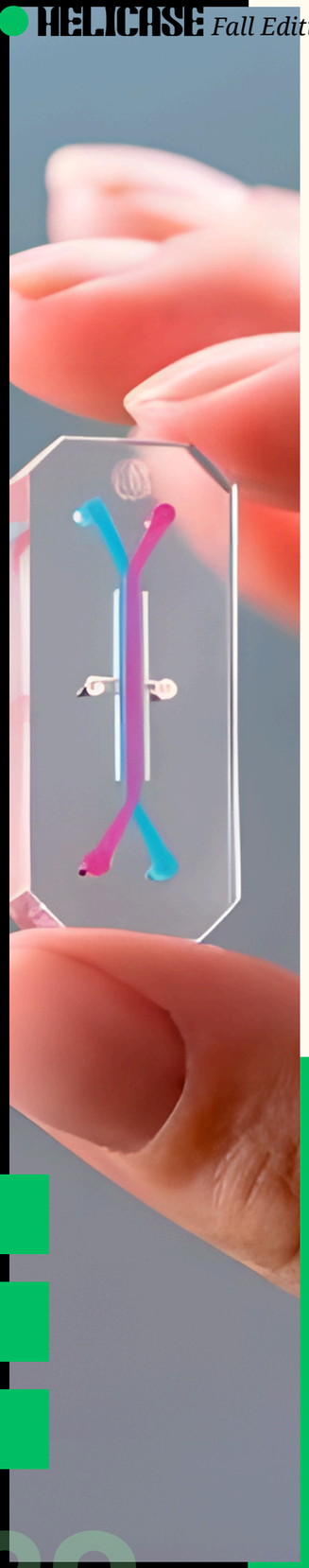
Beyond computing, time crystals could redefine precision timekeeping. Their periodic oscillations, inherently tied to their quantum nature, could lead to clocks with unprecedented accuracy, surpassing current atomic clocks. This could impact fields from GPS to fundamental physics experiments.

A recent breakthrough in 2023 demonstrated a two-dimensional photonic time crystal using metasurfaces—engineered surfaces that manipulate light. Unlike bulk 3D materials, these 2D systems simplify experiments and amplify electromagnetic waves traveling along surfaces. This could lead to more efficient integrated circuits and faster wireless communication systems, inching us closer to enhanced connectivity, though a fully "unwired" society remains a distant goal.

Despite these advances, time crystals are delicate. Their stability depends on precise control of interactions and driving fields, and environmental noise can disrupt their oscillations. Extending the lifetime of DTCs and scaling them to practical applications are ongoing challenges. Moreover, while photonic time crystals show promise, their integration into real-world technologies requires further development in materials and fabrication techniques.

The study of time crystals invites us to reconsider our relationship with time itself. Their rhythmic, self-sustaining oscillations challenge our intuitive understanding of a universe governed by static laws. They echo philosophical debates about free will, as the spins' "choice" to lock into a specific frequency resembles a kind of autonomy within a driven system. Yet, this "free will" is tightly constrained by quantum mechanics and external fields.

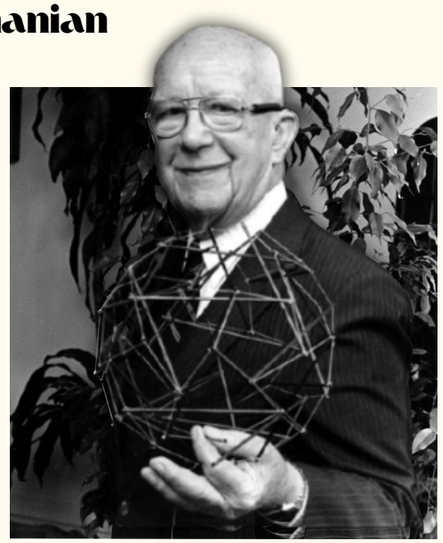
Time crystals have evolved from Wilczek's bold hypothesis to tangible quantum systems with real-world potential. They don't defy the laws of physics but expand our understanding of symmetry, time, and quantum behavior. As we refine these systems, we can unlock technological breakthroughs—one tick-tock at a time.



ME ON A CHIP... U ON A CHIP... WE ON A CHIP... IT'S POSSIBLE? IT'S PROMISING!!!

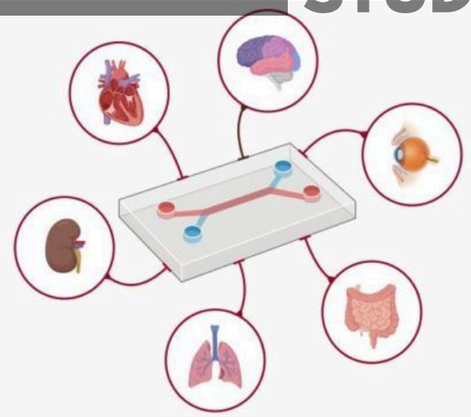
- Yashvita Subramanian

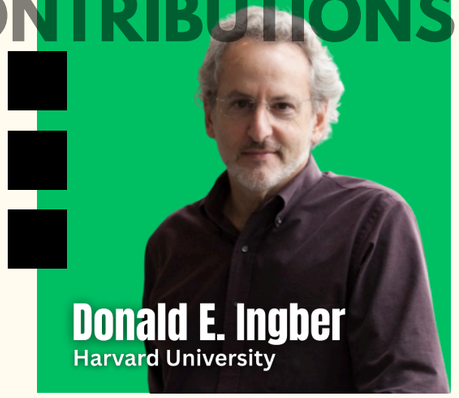
Ever seen Kenneth Snelson's artwork? Could tensegrity structures and therapeutics have anything in common?
A self-stabilized tensegrity structure composed of six wood struts balanced by multiple tensed cables. In a sculpture class, Donald observed that such a structure flattened when pressed down and then leaped off the surface and restored itself to this rounded form upon release.



Donald E. Ingber, at Harvard University, saw a commonality that sparked an innovation; that changed how personalized medicine was visualized. Being a mechanobiologist, Ingber, realized how forces set out by adjacent cells and extra-cellular matrix regulate cell physiology runs parallel to the behaviour of these rod-rope structures under application and removal of external force. And lo! The revolutionary technology of organ-on-a-chip was born.

A microfluidic device fabricated out of flexible polymers mimics the physiological state of the cells. It consists of nano-tubes of cell-lined membranes subjected to shear by nutrient-fluid flowing over them. Lungs were the first organ replicated on a chip in the year 2010. The mechanical compressions of the tube walls simulate conditions that imitate natural breathing movements. Models of the heart, brain, kidney, and blood-brain barrier soon followed.





Why Organ-on-a-chip?

Many drugs fail at clinical trials annually due to biological differences between us and the animal models they were tested on. Organ-on-a-chip promises to expedite the delay between drug conceptualization and approval by providing alternate and more reliable testing models. It also relieves those confounded by the ethical dilemma of subjecting animals to novel medications (pre-clinical). Cell cultures were often undependable, for cells outside the body do not behave in the same way after being ripped off their native environment.

"Think of the chip like a home away from home for an organ. We can control the way cells interact with each other by applying relevant mechanical forces."
– Geraldine Hamilton, President and Chief Scientific Officer at Emulate

In the wake of the Human Genome Project, individual differences have increasingly been realized to have immense relevance to medicine, particularly cancer. Personalized medication was seen as a futuristic world; no more with organ-on-a-chip. One can design their own organ on a chip using one's cells. Making this technology affordable will bring personalized health solutions to doorsteps. Population variations owing to gender and age can be tackled by having a population of different cell types. This will help make better predictions on generalized medications too. Introducing species-specific cells can help gain new insights into biological differences. This method can help ensure that farm pesticides are unharmful to the key species of the ecosystem. Pharmaceuticals are not the only ones on the winning side. The cosmetic industry will gain from testing product compatibility on the skin-on-chip. Recent research has uncovered novel applications of organ-on-a-chip in detecting biological warfare.

HOW organ-on-a-chip? What's next?!
Innovation does not end here. Combination of multiple organ-on-a-chip functions to represent a miniature living system, notably regarded variously as "body-on-a-chip" or" human-on-a-chip." This yields significant potential for testing new medications and their side effects on multiple organs. This facilitates pharmacokinetic study involving quantifying absorption, distribution, metabolism, and excretion (ADME) of substances.

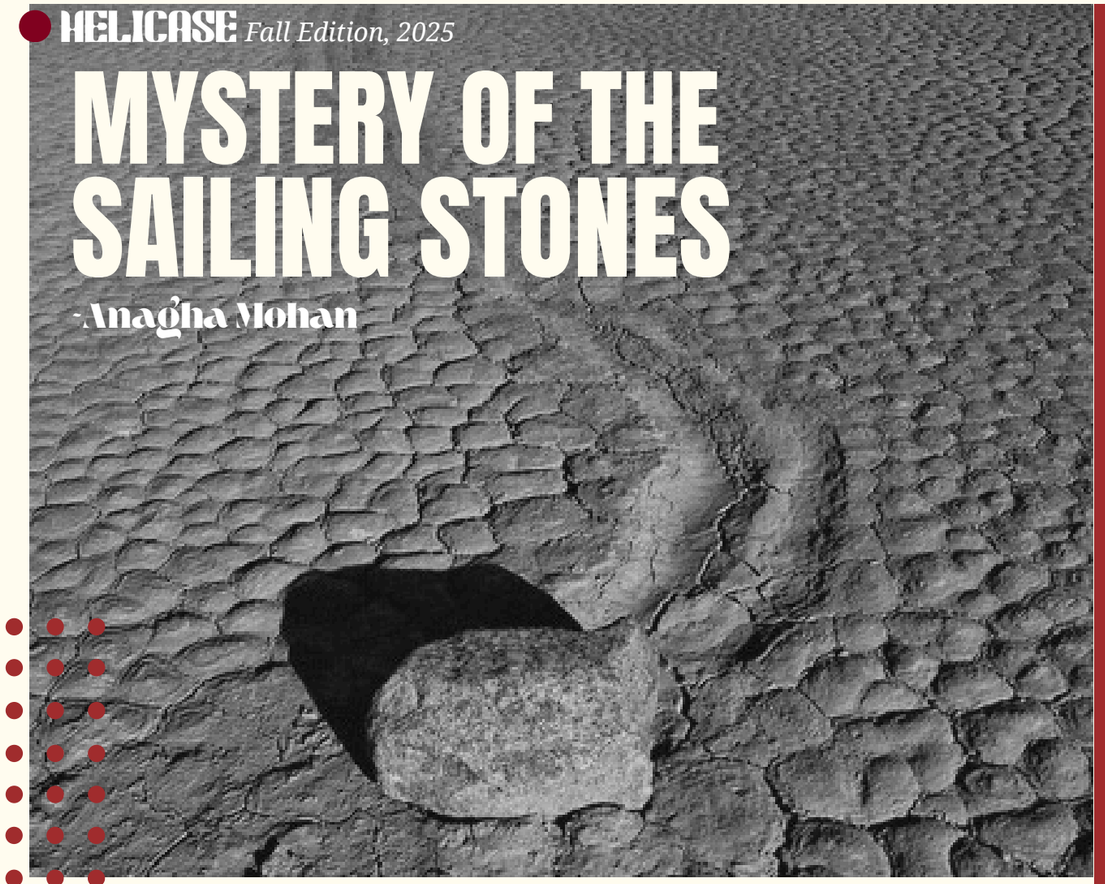
A team of scientists from Northwestern University has recently developed EVATAR, a 3D organ-on-chip model of the female reproductive tract, which can mimic a normal 28-day hormone cycle. Comprising the uterus, ovary, fallopian tube, uterus, cervix, and liver, EVATAR is actively used to learn more about cervical cancer and endometriosis and check out the efficacy of known drugs to treat them. Leading companies/tech giants like Merck and Johnson&Johnson have adopted this technology to model various disease conditions. This is bridging the academia and the industry. Investigation on the safety of drugs for treating Parkinson's Disease, cystic fibrosis, thrombosis, asthma, and viral infection in the lung. Still, many technical challenges, including scaling from microsystems to human beings, confront the researchers. These are being steadily addressed. Companies like Emulate, founded by Donald Ingber; and Hesperosare are pioneering this technology. Their efforts are being supported by both the public and the private sectors.

I was super-excited to learn about this wonderful science application that can potentially revolutionize how we study toxicity, drug efficacy, or just micro-physiology.

Just like the electronic chip transformed our lives decades ago, this innovation in the Wyss Institute is a game-changer FOR the healthcare sector. Life is no longer sci-fi; we are accelerating toward a very futuristic and promising techno world!!!

MYSTERY OF THE SAILING STONES

-Anagha Mohan



Nature is full of unique and mind-boggling phenomena that take scientists trying to understand them from the top of the mountains to the bottom of oceans. One such phenomenon is that of the sailing rocks.

On the Racetrack playa in Death Valley, the hottest, driest and below-the-sea-level desert basin in North America, are found rocks that leave behind tracks on a nearly flat dry mud lakebed. Almost no one has ever seen them move and yet it is evident that they do from the tracks they leave. Interestingly, most rock tracks of diverse-sized rocks are approximately parallel with synchronous sharp turns. The explanations for the tracks have ranged from wind, water, magnetism, and ice to magic and alien intervention!

Previous Explanation

Two forces control the rock's motion: the friction between the rock and the lakebed surface, and the force applied by an external agent. On a nearly flat surface, gravity is not the cause of most rock motion. The first studies suggested that dust devils, small whirlwinds with a visible column of dust, were the external force and algal films reduced the friction between the surfaces. However, evidence for the algal films was not found and the wind speeds required to move the rocks are not achieved in this region. Further studies proposed that rocks freeze into large, thick sheets of ice, slightly lifting the rock and reducing the friction. The wind pushes the ice sheets and moves them along with the rocks inside them. This however does not explain the non-parallel rock tracks or why in a group of closely placed rocks, some rocks move and others don't. Additionally, the tracks are deep, not shallow as they would be in the case of lifted rock.

Closest to the Truth?

For the first time in history, 70 years after the discovery of this phenomenon, the rocks were recorded moving on tape. In 2014, Richard and James Norris, a cousin duo of scientist and Research engineer, and their team set up rocks with GPS trackers and a weather station at the Playa to deduce when and under what conditions the rocks moved. Coincidentally they happened to be in the field when the rocks moved. After a winter storm, a small pond formed on the Playa, and thin windowpane ice was formed. The early morning sun broke the ice into small sheets and they floated on the water. The ice concentrated the wind stress, like sails gathering the force of the wind and pushing the hull of the ship, and focused it onto the rock which by itself would not have had the surface area required to move under relatively low-velocity winds. Under this force, the rocks started to move but at speeds of 0.12 - 0.3 kmph. Any casual observation is tough at such low rates, especially if the surrounding rocks are also moving and there are no good reference points. The ice melted away into the morning and all the water evaporated leaving the tracks and the rocks behind. Rocks shorter than the depth of the pond formed, massive rocks, and rocks at the edge of ice panes may not engage with the ice properly enough to move so not all rocks move. Broken ice sheets also explain why some tracks are not parallel. Because of infrequent winter precipitation, rocks move rarely.

Conclusion

In conclusion, the mystery of the sailing rocks in Death Valley's Racetrack Playa has been solved through recent research. The rocks move when thin ice forms on the playa, concentrating wind stress and providing the necessary force for their slow movement. This discovery sheds light on the previously unexp-lained phenomenon and adds to our understanding of the unique and intriguing wonders found in nature.





CRITICAL PROBLEMS OPTIMAL SOLUTION

Obviously, this writer will be called a lunatic hypocrite if the substitution of so-called 21st-century things with 18th-century belongings is suggested in this article. We are not doing that here. Instead, we will talk about a mathematical method dating back to the late 18th century that has flourished recently in both pure mathematics and machine learning, and this 'Jack of all trades, Master of none' character of our story is the concept of Optimal Transport.

It would be cruel of me to deliberately try to throw some hard mathematical terminologies at you. That is why we will talk about what made optimal transport important enough in the first place, i.e., the problem it addresses, and how we can use the same method in different cases.

Trust the lord of mathematics; the applications are brilliant, and it boosts the power of logical thinking and pattern learning to unprecedented levels. Imagine a city with several paper-making factories and book printing presses. The printing presses faced challenges as they wasted time and money traveling around to collect papers from the factories. These delays affected the printing process and the publication of books. The task at hand was to minimize the cost of transport while considering time efficiency. This situation is similar to an ore-mine problem.

Monge encountered a similar problem and set out to solve it. To describe the Monge problem, we often use the analogy of transferring mass from a pile of sand to a hole that needs to be filled as well. Coming back, Monge made the assumption that each paper factory could cater to only one printing press. The objective was to find an optimal solution by assigning each paper factory to a printing press through a function called the Monge map (denoted as T). This optimal assignment would consider factors such as distances between the factories and the presses, as well as their respective demands and production capacities. Now that we have a brief overview of the problem , in technical terms, Optimal transport gives a framework for comparing measures μ and ν where one pays a cost for transporting one measure to another. Assuming both measures are probability measures on spaces X and Y respectively $C : X \times Y \to [0, +\infty]$ is a cost function where $c(x, y)$ measures the cost of transporting one unit of mass from $x \in X$ to $y \in Y$. The problem basically wants us to minimize the cost of transportation. We say T: $X \to Y$ transports μ to ν where we call T a transport map, if $\nu(B) = \mu(T^{-1}(B))$ for all ν measurable sets B .

Monge assumed the production of one whole factory isn't split when it is transported to the printing press, but that made the quest of T hard. That is why this guy named Kantorovich thought to split the production and send them to different printing presses. This problem is called the Monge-Kantorovich problem, where we want to find a (probabilistic) function T that is allowed to split the production of farms among all artisans instead of finding a T that assigns each factory to one press. This problem can be shown to always have a solution under some assumptions related to the distance, which makes the distribution of materials easier.

It took almost two hundred years to fully characterize this problem until Yann Brenier showed that we can have a solution to this in the general case for some common distances used in science.

Although one may find these stories rather simple, made-up, or childish, the true power of our main character is hidden in its ability to act as a mechanism for transforming one (continuous) probability distribution into another one while minimizing the effort.

In a more complicated and realistic framework, the duality theory comes into play.

We try to find the best way to transport the resources by minimizing the total amount of resources moved or the distance traveled, and we look at the costs associated with transportation. This is really useful because it allows us to solve transportation problems more efficiently.

While Optimal Transport finds the most efficient way of transforming one distribution into another, we can use its solution to obtain intermediate trans formations as well. Our dear optimal character can be a one-shot solution to brain decoding in neuroscience, shape reconstruction in computer graphics, color transfer in computer vision, automatic translation in neural language processing, transfer learning, image registration, and spectral unmixing for musical data. This is precisely the reason this concept is so widely and frequently discussed nowadays (2 field medals in 12 years!).

With the advancement of science, the ongoing debate revolves around the potential dominance of machine learning and artificial intelligence, justified because we now have the ability to alter various aspects of a photo, such as its colors and the way it is captured. For instance, if we wish to transfer the style from one image to another, we can treat both images as probability distributions represented by 3-dimensional vectors in the RGB color space. By aligning a selected number of pixels using optimal transport (OT), we have the capability to completely transform a photo. Even Photoshop is another example of OT, used to edit an image by replacing a part of it using a part of another image; optimal transport is applied to color gradients of the two images, and then the Poisson equation is solved to calculate the edited image.

In automated translation, we define a distribution over each proposition and treat each word as a single point. Then we use the distances between their embeddings to match the two distributions with OT. One can take an MRI of a brain from a certain angle, and when a surgeon cracks the skull open, we can use optimal transport to know exactly where to cut. Lighting companies use OT to design certain patterns of lenses, it is used in seismology, and nowadays with the advancement in the field, regular usage of Optimal Transportation in machine learning is also noticed.

While one is advised to never try to be a Jack of all trades and master of none, our main character, Optimal Transport, has managed to come close to being just that—nearly, optimally, a master of all.

~Rupsa Chatterjee



Predictive Modelling in Biology

~Suhani Bhattacharyya

What is Predictive Modelling?

Creating mathematical models to explain and predict the behaviour of various components being studied using statistical tools is an important aim in scientific research. The goal to create a unified field theory to describe the interactions between elementary particles and all fundamental forces using a single theoretical framework can be considered as such a predictive model. It would help explain how space and time behave and change under different parameters.

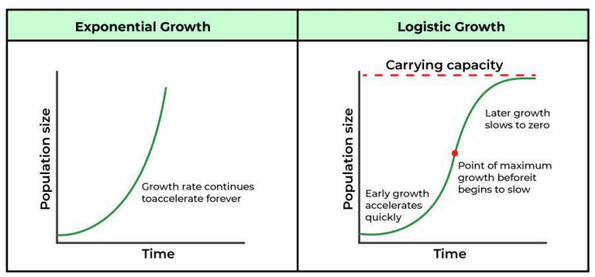


Fig. 1. Population dynamics graphs

Even after large scale projects for mapping and quite a few basic models already made, why is it so difficult to make a concrete predictive model in biology?

The complexity of organisms, from a unicellular bacterium to the human body, is a result of many stochastic changes during their evolution. Evolutionary modelling itself is an active field. Equations for population dynamics are an example of such a predictive model. The aim is to make these models resemble reality and even try to incorporate intricate interactions. Similar interactions pose a problem for molecular modelling of enzyme kinetics. However, this is much more difficult than using simple discrete differential equations for a population. Consider the Hardy-Weinberg equilibrium. It can predict the population number pretty accurately for isolated lab settings. However, it imposes a bunch of conditions which eliminate all external influence on the population. In nature, this is almost impossible. Interaction between different communities along with the non-living environment must be factored in. Then there is the occasional asteroid impact and volcano eruption. All these factors make declaring any one evolutionary model, or really any biological model as predictive for all the dynamics of all living organisms almost impossible.

How are these models made?

Simple mathematical modelling uses two variables and arbitrary constants, which are found by graphing. Dynamic modelling describes changes in these systems over time. Discrete ones describe simple mathematical equations and focus on one parameter at a time. Continuous dynamic models use ordered differential equations (ODEs) and factor in changing rates of variables over time. These are the types of models currently being used for ecological and evolutionary modelling. Other than that, one of the most important goals of predictive biology is figuring out the different '-omes'.

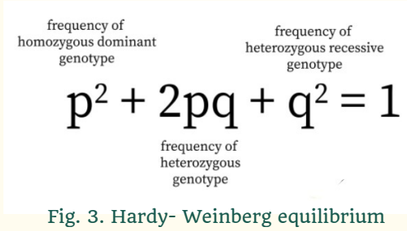


Fig. 3. Hardy- Weinberg equilibrium

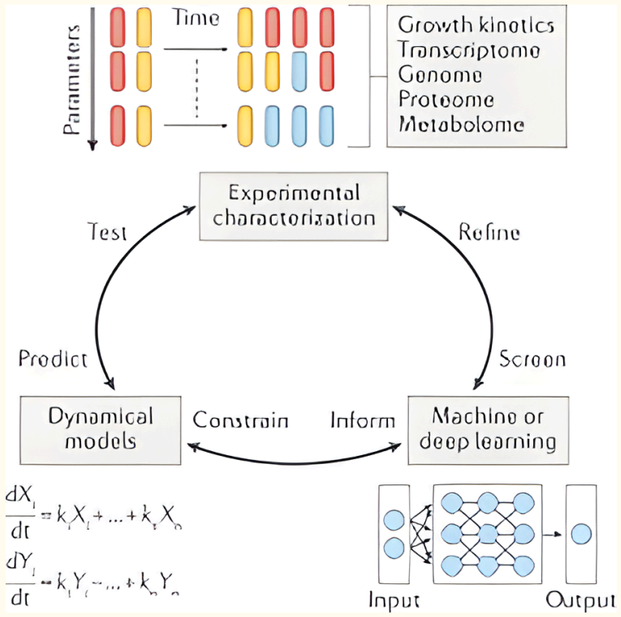


Fig. 4. Biological modelling

For example, the interactome is the complex network of protein interactions with other proteins as well as with nucleic acids. Tools to understand the interactome are still being developed and refined. Experimental verification of biochemical pathways and protein interactions is the most reliable way for mapping the interactome at the moment. However, it is a long and arduous process as it only provides stepwise information. Often experimental methods are like finding a needle in a haystack. Someone thinks they have figured out every protein involved in the pathway, the next day someone else's paper is published with yet another protein that may be involved in the same pathway. The protein might even have multiple roles in the same pathway, or the same role in different pathways and trying to understand it through experiments often leads to conflicting results in different papers published. Thus, nowadays experiment is accompanied by theoretical modelling of the protein structure and function. In fact, structural biology is a field that uses structure of proteins to predict its function and place in the interactome. The information for this modelling is stored in databases such as the Database for Interacting Proteins. It provides researchers with the information required for their work including amino acid sequences, tertiary and secondary structures, function, source organism, place of occurrence and literature related to the proteins.

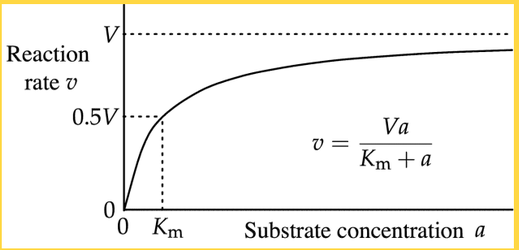


Fig. 2. Michaelis-Menten equation for enzyme kinetics

Why do we need to make these models?

One of the goals of creating these databases and making a predictive model is to be able to find the source of diseases and infections. Instead of treating the symptoms, modelling the biochemical pathways would help treat the cause of diseases, such as cancer. Improving accuracy of predicting protein functions would help get to the root of neurodegenerative prion diseases such as BSE and even Alzheimer's. Making predictive models would also improve safety standards of treatments because we would be able to understand the long term consequences and ripple effects of any fertilisers or drugs. Research in biology is not about putting out fires as they come along, instead it is about understanding the reasons behind the various behaviours and phenomena.

● HELICASE *Fall Edition, 2025*

JURASSIC BARK

~Saranya Ray (aka Remus)



In a world grappling with climate chaos and vanishing species, one biotech company is howling back at extinction-literally. Colossal Biosciences, a $10.2 billion synthetic biology startup, is taking on the Ice Age's most iconic predator: the dire wolf. But forget dusty fossils and Jurassic Park fantasies, this isn't about cloning ancient DNA. It's about crafting modern-day lookalikes with fangs, fur, and ferocity to match.

And leading the pack? Romulus, Khaleesi, and wait for it...Remus. That's right. As someone who goes by Remus, I'm not saying I was destined to write about genetically engineered pseudo-dire wolves... but the universe clearly has a sense of humor. These engineered canids, born between late 2024 and early 2025, may not be dire wolves by name, but in size, behavior, and presence, they're the closest thing we've had in over 10,000 years.

From Petrified to Personified

Dire wolves (*Aenocyon dirus*) were apex predators during the Late Pleistocene and roamed vast stretches of North America. For decades, scientists assumed they were closely related to grey wolves (*Canis lupus*). However, groundbreaking genomic research by Perri et al. (2021) revealed that dire wolves diverged from the lineage leading to grey wolves nearly 5.7 million years ago, forming a genetically distinct branch of canids.

This phylogenetic distance rules out classical cloning or selective breeding methods as viable routes for de-extinction. No intact genome of *A. dirus* exists. This barrier prompted researchers to consider phenotype-first reconstruction, focusing on visible traits derived from partial ancient DNA and inferred fossil data.

So Colossal's dire wolf project began with DNA fragments extracted from ancient remains; a 13,000-year-old tooth in Ohio and a 72,000-year-old ear bone from Idaho. These relics, housed in museums, were sequenced to identify the genetic blueprint of the dire wolf, focusing on traits that set it apart from the gray wolf.

Scientists pinpointed 20 critical traits embedded in 14 genes that gave the dire wolf its distinctive look and behavior: broader skulls, wider jaws, increased muscle mass, longer limbs, white coats, and even howling and whining vocalizations.

Instead of using invasive tissue samples, Colossal harvested endothelial progenitor cells (EPCs), which line blood vessels, from living gray wolves. The 14 target genes in these EPCs were edited using CRISPR-Cas9 to emulate dire wolf traits. Crucially, this did not involve inserting ancient DNA. Instead, modern wolf genes were rewritten to functionally resemble their ancient counterparts.

Some gene edits proved delicate: three genes responsible for pale fur also risk causing deafness or blindness in wolves. To avoid this, scientists engineered pigment-suppressing genes that could mimic dire wolf coloration safely. Once modified, the nuclei of these edited cells were implanted into enucleated gray wolf ova, which were then nurtured into embryos and inserted into surrogate hound dogs selected for their health and size. Out of 45 engineered ova, three pregnancies reached full term. Romulus and Remus were born on October 1, 2024, followed by Khaleesi on January 30, 2025. All three births were scheduled cesarean deliveries with no reported complications or stillbirths.

As TIME reported, the goal wasn't revival, it was recreation. The result? Animals that 'look like dire wolves, act like modern wolves, and are genetically still wolves'.

> *"We're not bringing back a carbon copy. What we're building is a proxy that can fulfill the ecological role of the extinct animal,"*
>
> —Ben Lamm, Colossal Biosciences CEO

The proxies exhibit broader skulls, elongated limbs, and dense fur that matches Ice Age reconstructions—but their genome remains over 99.5% gray wolf.

It Takes a Village to Raise a Wolf

Raised under meticulous care at a 2,000-acre secret preserve, the three young canids have exhibited what Colossal calls wild lupine behavior. Unlike domestic puppies, Romulus and Remus keep a cautious distance from humans, retreating even from handlers who bottle-fed them as newborns. They began howling at just two weeks old and showed early signs of stalking and hiding instincts.

> *"From day one they have always behaved like wolves and have rarely shown doglike behavior,"*
>
> —Paige McNickle, Colossal's manager of animal husbandry

The preserve, surrounded by a 10-ft fence, features dens, shelters, a veterinary clinic, and an area where the wolves can express natural behaviors like tearing meat. Their diet includes beef, horse, deer meat, and nutrient-rich puppy chow. So far, they have not hunted live prey, though staff believe their instincts are intact. Each pup also has a distinct personality. Romulus, initially the braver explorer, has given way to a bolder Remus as they grow.

One Small Step for Man, a Mammoth Step for Mankind

While the visual resemblance is uncanny, most scientists agree: these animals are not dire wolves. According to Dr. Angela Perri, the divide between them and modern wolves is so vast that these proxies are more like lookalike actors than resurrections.

> *"You can't edit your way into making a dire wolf. It's like trying to turn a house cat into a tiger by changing a few genes."*
>
> —Dr. Angela Perri, archaeozoologist, Durham University

Even Colossal admits the proxies aren't genetically identical. Behavioral traits, vocalizations, and ecological instincts are unknown. And the ethical implications of calling them "dire wolves" are murky.

Colossal insists that their dire wolf work is not about spectacle or nostalgia, it's about building tools for conservation. As species continue to vanish, techniques refined on extinct animals may help bolster existing ones on the brink.

The company is already applying its EPC cloning method to red wolves, a critically endangered species once common across the U.S. Southeast. Only around 20 red wolves survive in the wild, plagued by poaching and vehicle strikes. The species also suffers from a genetic bottleneck, leading to fertility issues and inherited defects.

To combat this, Colossal recently cloned four red wolves using ghost alleles, genetic traces of red wolves found in coyote-like canids from Louisiana and Texas. These ghost wolves could help diversify the red wolf gene pool, and Colossal is now in advanced talks with North Carolina's state government on red wolf conservation strategies.

> *"It's the lost genetics of the world's most endangered wolf. And we now have the opportunity to use our cloning and genetic-engineering tools to be able to confer that genetic diversity back into the recovery of the species."*
>
> —Matt James, Colossal's chief animal officer

The company aims to produce a woolly mammoth calf by 2028, using gene-edited Asian elephant embryos to emulate the mammoth's cold-adapted traits like thick fur and subcutaneous fat. As of early 2025, Colossal had already edited 25 out of 85 target genes and produced 'woolly mice, lab rodents with mammoth-like features such as shaggy coats.

Though the final mammoth will technically be an Asian elephant with mammoth traits, Colossal argues that functional equivalence is what matters. If it behaves and reproduces like a mammoth, isn't it a mammoth in all but name?

> *"Our mammoths and dire wolves are mammoths and dire wolves by that definition. They have the key traits that make that lineage of organisms distinct."*
>
> *—Beth Shapiro, Colossal's chief science officer*





> *"In the moment of any choice, the first thing to do is the right thing. The next thing to do is the wrong thing. The worst thing to do is nothing at all."*
>
> —Matt James, paraphrasing Teddy Roosevelt

Gen-ethics

Colossal's work raises profound ethical and ecological questions. Critics warn of pleiotropy where one gene affects multiple traits unpredictably and of the long-term impact of releasing engineered animals into the wild. Past examples, from cane toads in Australia to Burmese pythons in the Everglades, show how human intervention can spiral into ecological catastrophe.
Experts warn of unintended consequences if such predators were introduced into the wild. Hybridization, unexpected behaviors, or shifts in prey populations could disrupt ecosystems rather than restore them.

> *"You're not restoring nature. You're creating something new and releasing it into an environment that may not be ready for it."*
>
> —Dr. Jeremy Austin, evolutionary biologist, University of Adelaide

Genes with Strings Attached

As a species, we continue to crowd out the rest of the planet's biodiversity. Colossal is attempting something once unthinkable: to reverse that damage, one edited genome at a time.

Functional de-extinction could, in theory, serve conservation goals by reintroducing lost ecological functions. For example, the reintroduction of horses in North America has been cited as an analogue for extinct Pleistocene equids.

However, critics such as Mech (2025) caution against prioritising resurrected proxies over living, endangered species in immediate need of habitat protection and policy intervention.

"We're engineering ghosts when the living world is crumbling beneath us."

If functional analogues do play a role, they must be as complements, not replacements, in broader ecosystem management strategies.

Whether their work represents redemption or recklessness remains to be seen. But one thing is certain: Romulus, Remus, and Khaleesi are no longer just symbols of myth, they're the living faces of a new kind of science.

HELICASE *Fall Edition, 2025*

ABSTRACTION TO REALITY

Why is Mathematics Such a Powerful Tool to Describe Nature?

Since its inception, mathematics has been a strong catalyst for paradigm shifts in natural philosophy. Physics began around 600 B.C., when Pythagoras of Samos proclaimed an awesome vision. By studying the notes sounded by plucked strings, Pythagoras discovered that the human perception of harmony is connected to numerical ratios, which became the credo of the Pythagorean Brotherhood. The Pythagoreans, and several subsequent philosophers, believed that Natural phenomena are innately mathematical, and mathematical aesthetics are not only superficial, but essential for the universe to work the way it does.

Newton's arrival implied a long eclipse for the Pythagorean ideal of a mathematically sophisticated Creator. Newton's classical treatment of mechanics attributed everything to dynamics. The great developments of nineteenth-century physics, epitomized in Maxwell's equations of electrodynamics, brought many new phenomena ena within the scope of physics. Still, they did not alter this situation essentially. However, the advent of quantum mechanics reinforced the Pythagorean ideal among physicists and philosophers.

Emblematic of the new physics, and decisive historically, was Niels Bohr's atomic model of 1913. The leitmotif of Bohr's model is unmistakably mathematical. If anything, Bohr's model conforms more closely to the ancient Pythagorean and Platonic ideal that 'God is a mathematician, and his every creation must be worthy of a mathematically inclined creator'. Later work by Heisenberg and Schr¨odinger, which defined modern quantum mechanics, superseded Bohr's model. This account of subatomic matter is less tangible than Bohr's, but ultimately much richer. The mathematics describing the vibratory patterns that define the states of atoms in quantum mechanics is identical to the mathematics describing the resonance of musical instruments. The stable states of atoms correspond to pure tones. The big difference between Nature's instruments and those of human construction is that Her designs depend not on craftsmanship refined by experience, but rather on the ruthlessly precise application of simple, mathematical rules.

To highlight this beautiful coherence between mathematics and natural phenomena, in 1960, the celebrated theoretical physicist Eugene Wigner published an essay, 'The Unreasonable Effectiveness of Mathematics in the Natural Sciences'.

This was directly a result of his surprise at the connections he had discovered between quantum mechanics and the theory of group representations – a seemingly unrelated area of mathematics developed some 50 years earlier.

He could hardly have predicted what would occur 20 years later in the opposite direction: an essay by the celebrated mathematician Sir Michael Atiyah, titled, 'The Unreasonable Effectiveness of Physics in Mathematics'. In his essay, he argues that the toolbox of a physicist enables a practitioner such as Edward Witten to make significant contributions to pure mathematics as well. As is well known, Ed Witten won the Fields Medal in 1990, and continues to be the only professional physicist to have ever achieved such a feat.

So what makes Mathematics and Physics so interrelated? Several luminaries in various fields asked the same question, and it invoked many responses across a wide range of disciplines. The absurdity of the responses ranged from the famed Richard Hamming boldly stating that the 'usefulness' in question is nothing but an illusion, and humans usually create mathematics to suit the situation. On the other hand, Max Tegmerk, a theoretical physicist, claimed that all of reality is just mathematics. All mathematicians do is discover (or invent? That's a tale for another time) simpler mathematics to model our more complex and inherently mathematical universe. However, most of these responses were only 'partial explanations', and hence why mathematics and physics overlap still lacks a definite answer.

But let's get back to what really got Wigner started on the question in the very first place- the birth of quantum mechanics. Wigner summarizes his article by saying that "the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it". He concludes his paper with the same question with which he began:
"The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning."

~Anargha Mondal





INTERNSHIPS & SCHOLARSHIPS

INTERNSHIPS & SCHOLARSHIPS

Summer School for Women in Mathematics and Statistics	ICTS, Bangalore	Women students studying in first year B.A/B.Sc./B.E./B.Tech. or equivalent degree and having Mathematics as one of the major subjects/courses
Mathematics Training and Talent Search (MTTS) Program	changes every year	Undergraduates and Graduates
Summer Programme in Mathematics (SPIM) in Mathematics	Harish-Chandra Research Institute (HRI)	Students interested in carrying out their 4 year BS thesis / master's thesis work (as part of degree requirements at their home institution) in Mathematics and Theoretical Physics under the mentorship of HRI faculty.
TIFR Summer Student Reasearch Program (Mathematics)	TIFR Bangalore	Anyone who is currently pursuing a Bachelor's or Masters's degree in mathematics, science or engineering fields anywhere in India.
IWM Summer School	The Department of Mathematics, CHRIST (Deemed to be University)	Young women students
Kerala School of Mathematics (KSoM) Summer Internship	Kerela School of Mathematics (KSoM)	Students who have completed their second year BSc in Mathematics
S. Ramanujan Centre Summer Training Program in Mathematics	University of Madras	Students who have completed I year M.Sc. / IV year Integrated M.Sc. Mathematics
NCM Summer Schools in Mathematics	National Board for Higher Mathematics	Ist year PhD students and onwards
Shraman Mathematics Scholarship for Brilliant Students in Mathematics	The Shraman Foundation	School students between 13-18 years and Undergraduates under 22 years old
Young Researchers in Mathematics Program	Bernoulli Center for Fundamental Studies	Students not in a PhD program but who show an interest towards pursuing a PhD in Mathematics
CMI Summer Internship	CMI, Chennai	Students should have a background in programming, and preferrably some exposure to algorithms and/or automata theory. Typically, CMI does not offer internships to students before the end of their second year of college/university.
CERN OpenLab for Computer Science Undergraduates	CERN	B.Sc. or M.Sc. student in computer science, mathematics, engineering, or physics
ISI Summer Research Internship Program	Information Sciences Institute, USC	Qualified PhD students and highly talented undergraduates
Visiting Students Programme (VSP)	Harish-Chandra Research Institute (HRI)	Students in M.Sc, B.Tech and final year B.Sc programmes
Summer School for Women in Physics	ICTS, Bangalore	Women studying for a bachelor's degree/Integrated Masters degree with physics as a subject, and are entering their second year
Saha Institute of Nuclear Physics Undergraduate Associateship	Saha Institute of Nuclear Physics	Undergraduates
CeNSE Summer School	IISc	UG/PG students
Visiting Students' Research Programme (VSRP)	National Centre for Radio Astrophysics, TIFR	Only students who are entering the final year of B.Sc./M.Sc. degrees (in Physics/Astronomy/Applied Mathematics/Electronics) or B.Tech./B.E. degrees, or students in the final year of the B.Sc. degree, or students completing the third or fourth years of an Integrated M.Sc. degree in Physics/Mathematics
Physical Research Laboratory Summer Internship Programme	PRL, Department of Space, Government of India	Graduate and postgraduate students and college teachers of Indian Nationality
Indian Institute of Astrophysics internship Programme	Indian Institute of Astrophysics	-Students in the final year of B.E/B.Tech/M.Sc/M. Tech and want to undertake final year project work towards partially fulfilling their degree course. -Students holding a B.E/B.Tech/B.Sc/M.Sc/M. Tech degree and want to undertake a short-term project at IIA (three- to twelve-months). -Students pursuing Ph. D. at other Institutions/universities/Colleges and want to visit IIA for collaborative work with any IIA faculty (for a maximum period of six months). -Students submitted their Ph.D thesis and awaiting thesis defense (for a maximum period of six months).
CERN Summer Student Programme	CERN	Students pursuing bachelor's or master's degrees in physics, computing, engineering and maths
PSI Summer Student Programme	Paul Scherrer Institute	Students who are about to finish their bachelor's degree and those enrolled in a master's programme at a university
Caltech SURF	Caltech	-Be a continuing undergraduate student and eligible for fall term registration -Have a cumulative GPA of at least 2.5/4.0 -Complete the second semester or third quarter at your college or university -Not be under any academic or disciplinary sanction.
Space Astronomy Summer Program	Space Telescope Science Institute	Upper-division undergraduates with a strong interest in space-based astronomy, engineering, or public outreach
Nordita Summer Internship Program in Theoretical Physics	Nordic Institute for Theoretical Physics (Nordita)	Master's student (in the exceptional cases advanced Bachelor's students will also be considered)
Summer Students' Visiting Programme (SSVP)	Institute of Physics Bhubaneswar	Strictly those should apply who will complete their 2-yr. M. Sc. / Integrated M. Sc. in 2026, i.e., those who, by summer of 2026, are completing 1st year of 2-year M.Sc. or 4th year of 5-year Integrated M. Sc. Course.
RRI Astronomy Summer School (RASS)	Raman Research Institute	Students who will have completed at least 2 years (4 semesters) of their bachelors program (B.Tech/BS/ BE/BSc) by May 2025, and have not yet started their MS/MSc/M.Tech thesis work.
Introductory Summer School in Astronomy and Astrophysics	Inter-University Centre for Astronomy and Astrophysics	-Students in the final year B. Sc. (Physics/Applied Mathematics/Astronomy/Electronics) -Students in third year and onwards of B.Tech./B.E. (any branch) / Integrated M.Sc. (Physics/Applied Mathematics/Astronomy/ Electronics) -Students pursuing M.Sc. (Physics/Applied Mathematics/Astronomy/Electronics)
Vacation Students' Programme	Inter-University Centre for Astronomy and Astrophysics	-M.Sc. - First Year (Physics / Applied Mathematics / Astronomy / Electronics / Optics / Scientific Computing) -Integrated M.Sc. - 3rd and 4th Year (Physics / Applied Mathematics / Astronomy / Electronics / Optics / Scientific Computing) -B.Tech. / B.E. - 3rd and final year (Any branch) -Students who have completed the third year and are moving to the fourth year of the Four-year Undergraduate programmes in Basic Sciences
CHSL Undergraduate Research Program	Cold Spring Harbour Laboratory	Students must be returning to an undergraduate degree program following their URP summer research experience; current sophomores and juniors, or the equivalent, are eligible. Only in exceptional cases will

		first-year undergraduate students, with prior independent research experience, be considered.
Amgen Scholars Asia Program	University of Tokyo, Kyoto University, National University of Singapore, Tsinghua University	Enrolled in colleges or universities in Asia that award a bachelor's degree (or its equivalent); and at minimum, have completed their first year of undergraduate study at the time the summer program begins, and are not graduating before the summer program begins, and after the summer program ends will resume undergraduate studies for at least one semester or one quarter.
EMBL Undergraduate Internships	European Molecular Biology Laboratories	Undergraduates student's Diploma, Bachelor or Masters' thesis, but internships outside of the formal arrangement of an undergraduate thesis are also considered
CNIO Summer Training Programv	CNIO, Spain	Undergraduate university students in their final years of biomedicine-related studies in any country.
IBRO/RIKEN Summer Program	International Brain Research Organisation	Postdoctoral Fellows, PhD Students, Master Students, Bachelor Students, Medical Doctors (MD) (Students from all regions of the world are eligible to apply for this school).
ISTernship Summer Program	Institute of Science and technology Austria	-Applicants must have completed at least the second year or fourth semester of their bachelor's studies before the respective start date. -Students accepted to or enrolled in a PhD program are not eligible to apply. -Applicants who graduated within a year from the program start date are also eligible to apply.
University of Tokyo Research Internship Program	University of Tokyo	Students who are currently enrolled in the second or a later year at an accredited college or university outside of Japan, and who are majoring in a natural science or related field
Stowers Summer Scholars	Stowers Institute of Medical Research	-Completed one year of undergraduate studies by the start of the program -18 years of age or older prior to the program start date -Enrolled in or just graduated from a degree-granting program in biology, biochemistry, molecular biology, genetics, chemistry, physics, computing, engineering, mathematics, or a related field -Open to domestic (U.S.) and international students -Open to previous Summer Scholars -Students enrolled in or beginning a M.D. or Ph.D. program (in Fall 2025) are NOT eligible to apply -Those enrolled in a combined BS/MS program must be within the first 4 years of the program - equivalent to a U.S. undergraduate program
Short-term Internship/Training	Institute of Genomics and Integrative Biology	All students
Summer Training Program, CSIR-CCMB	Centre for Cellular and Molecular Biology	-M.Sc./ M.Tech/ M.Pharm Program: Students admitted in 2024 (who completed the first year of M.Sc./ M.Tech/ M.Pharm are eligible). -B.Tech./ B.Pharm Program: Students admitted in 2022 (who completed three years of B. Tech are eligible). -Integrated B.Tech-M.Tech or B.Sc-M.Sc. or BVSc: Students who completed the 8th semester (or four years of their study are eligible) -MBBS/ BDS students who have completed three years by January 2025 and pursuing their studies are eligible -B.Sc in Biosciences 4years program: Students admitted in 2022 (who completed three years of B.Sc are eligible) -Note: 3 years B.Sc program and Pharm.D students are not eligible.
NGSF Internship Program	Next Gen Scientists Foundation	Student in the (i) 2nd year of a 3-year undergraduate program or (ii) 2nd/3rd year of a 4-year undergraduate program or (iii) 1st year of a 2-year masters program or (iv) 2nd/3rd/4th year of a 5-year integrated program at an Indian institute in an unpaid internship, without a fee, not have previous fellowships
NISER Winter Internship Program	NISER	Students pursuing BSc, MSc, Integrated MSc with Biology as a major aubject
IBAB Internship Programme	Institute of Bioinformatics and Applied Biotechnology	Undergraduate and postgraduate students, who wish to carry out short-term projects in biotechnology, bioinformatics and big data in biology either as part of their course requirements, or for building essential research skills.
Summer Research Internship	School of Life Science, University of Hyderabad	Graduate / post graduate students in cutting edge areas of biology
Roche Internships in Medicinal CHemistry (RiCH)	Medicinal Chemistry laboratories in Basel, Switzerland	Passionate & motivated chemistry student who will be in the penultimate or last year of study, at the "Year in Industry" junction of their studies or in a gap year before starting a PhD
Summer Internships for Undergraduates	NCCR Bio-Inspired Materials	Undergraduate students
Student Internship Program	CSIR-NCL	UG (BE or B.Tech) and PG (ME, M.Tech, MSc, M. Pharm.) students from universities and colleges
Internship, LPSC	LPSC, ISRO	BE/B.Tech/B.Sc (Chem)/MSc (Chem) students who have completed their 4th Semester, ME/M.Tech/MSc (Chem) who have completed their 1st year, PhD students who have completed their course work (Students shall possess aggregate of Min 60% or CGPA 6.32 on a scale of 10).
Chemical Engineering Internship Programme (CEIP)	IISc	Undergraduate students, including those who directly contact the faculty as well as those nominated by their university's Chemical engineering
AIMS NEI Fellowship Program for Women in Climate Change Science	African Institute for Mathematical Sciences Next Einstein Initiative	Outstanding female scientists based anywhere in the world
IITM Summer Internship positions	Indian Institute of Meteorology	Students pursuing Masters degree in Science and Engineering
National Centre for Earth Science Studies Internship/Dissertation	National Centre for Earth Science Studies	Applications of only the following students will be considered for scrutiny and final acceptance. a) 5 years Integrated M.Sc./M.Sc. Tech./M. Tech.: Students from 7th - 9th Semester; b) 3 years M.Sc./M.Sc. Tech.: Students from 3rd – 5th Semester; c) 2 years MSc. /M.Sc. Tech. / M. Tech.: Students from 2nd – 3rd Semester; d) B.Sc Final year students;
Internship Scheme" of Ministry of Environment, Forest and Climate Change	Ministry of Environment, Forest and Climate Change	Applicant pursuing Graduation or Post-Graduation or Research Work from any recognized University/ Institution within India or abroad shall be eligible.
IISD INDIA - INTERNSHIP PROGRAMME	Indian Institute of Sustainable Development	Students pursuing a Masters / Bachelor's Degree in Science / Engineering / Commerce / Public Policy / Political Science / Economics / History / Law / Journalism and Communication.
INTERNSHIP/TRAINING/DISSERTATION AT NCPOR	National Centre for Polar and Ocean Research (NCPOR)	Applications of only the following students will be considered for scrutiny and final acceptance. B.Sc. / B.E. / BCA / B. Tech. - Final year students. M.Sc. / M.E. / MCA / M. Tech./ M.A - Pursuing. 5 years Integrated M.Sc./M.E./M. Tech. -Students from

		3rd year onwards Students in the final year of their MSc degree are also eligible to apply for internships within the same calendar year after completing their degree, provided they adhere to the prescribed recommendation format.
WMO Internships	World Meteorological Organisation	-Students approaching the end of their studies and preparing a thesis -Students who need an internship to complete their studies -Have recently graduated and are between the age of 21 and 35 years old -Have less than two years of relevant work experience -Hold a scholarship for an internship placement in an international organization -Are sponsored by a governmental/non-governmental entity such as an NGO -Are sponsored by academic institutions to work in specific areas within WMO
Dr. APJ Abdul Kalam Young Research Fellowship	funded by TERRE Policy centre	-Undergraduate, Masters in any of the field or appearing (M.Sc, MA, M.E and PHD or appearing) -Any citizen of India, who has not attained the age of 25 years on 31st December, of the year preceding the year of fellowship, shall be eligible for the fellowship.
SRFP by JNCASR	JNCASR	Students pursuing UG/PG programmes in the disciplines of Science/Engineering/Technology/Medicine/Veterinary Sciences
~~SRFP by IAS~~ IISER	IAS,INSA,NASI,CMI,ICTS,IMSc	Undergraduates from the second year onwards
Summer Student Research Program	IISERs	Undergraduates
S. N. Bhatt Memorial Excellence Fellowship Program	International Centre for Theoretical Sciences, (TIFR)	Undergraduate students of science, mathematics and engineering, who are in their third, fourth or fifth year of the program, as well as exceptional undergraduates in their second year
IMSc Chennai Summer ~~Research Program~~	The Institute of Mathematical Sciences	Students currently in their pre-final or final year of BSc/BE/BTech or first year MSc/ME/MTech or equivalent
Imperial College India Future Leaders Scholarship	Imperial College, London	Postgraduate taught, Master's research
Inlaks Shivdasani Scholarships	The Inlaks Shivdasani Foundation	Applicant must hold a degree from a recognised university in India or in the final year of graduation and awaiting results
Summer Undergraduate Research Exposure (SURE)	IIT Hyderabad	Should be a first year MSc (Maths/Physics/Chemistry/Biology) OR MA first Year OR MA Psychology 1st/2nd Year OR MSc Psychology 1st/2nd Year OR MRes Psychology 1st/2nd Year OR the 2nd/3rd Year B.Tech/ B.Des/B.Arch/B.A(All branches) OR the 3rd/4th Year Integrated B.Tech.-M.Tech. program. B. Applicants should be among the top 20% based on CGPA/% score in all the previous years in their discipline in the College/ Institution/University (certified by the Head of the Institute/Principal).
IISER Bhopal Internship Program	IISER Bhopal	Students who have completed or be currently studying in the 2nd, 3rd, 4th year of B.Sc/B.Tech/BS/BS-MS/B.E (or) 1st year of M.Sc/M.Tech (or) an equivalent program at the time of application are encouraged to apply.
Charpak Scholarships	Campus France India	Bachelor's and Master's levels, different scholarships
ThinkSwiss Asia-Pacific ~~Scholarship~~	Swissnex	Applicants currently enrolled in a Master's programme or have completed their second year of undergraduate degree by the time the research stay in Switzerland begins.
IIT Gandhinagar Summer ~~Research Internship Program (SRIP)~~	IIT Gandhinagar	Students pursuing a bachelor's or master's degree at a prominent institution in Indi
National Initiative on ~~Undergraduate Science (NIUS)~~	Homi Bhabha Centre for Science Education Tata Institute of Fundamental Research	Students in or who are going to be in the first year of their Bachelor's degree
OIST Research Internship Program	Okinawa Institute of Science and Technology	Those who are currently enrolled in their last two years of a bachelor's degree, enrolled in any year of a master's degree in universities, colleges, junior colleges, and vocational schools in Japan or overseas, or those who have graduated with a bachelor's or master's degree, are eligible to apply for the Research Internship at OIST.
Khorana Program	Indo-U.S: Science and Technology Forum	Pre-final year students enrolled in B. Tech., M. Tech., B.Sc., M.Sc., B.E., M.E., M.S., Integrated B. S-M.S., B.V. Sc., M.V. Sc., B. Pharm., M. Pharm., MBBS., and Master in Medical Science and Technology (MMST) at recognized institutions of higher education in India in Biotechnology and allied areas (including agricultural, food, health, biomedical sciences and interdisciplinary areas like Computational Sciences, Big Data, Machine Learning etc.) are eligible to apply. First Year, Final year and PhD students are NOT eligible to apply. Applications in subject - fields other than those specified above will not be considered. The applicant should have: Cumulative Grade Point Average (CGPA) of 8.0 or higher, OR Percentage: 80% and higher Minimum 65% and higher if the applicant is an MBBS student Preference will be given to students without prior international research experience.



BEST THESIS 2025

MS/PHD

BEST MS THESIS



Uyyashrinila P

Max Planck Institute for Biological Intelligence (MPI-BI), Martinsried

" Characterization of eomesa+ retinal ganglion cells in zebrafish "

Nature of Work: Experimental
Type of Thesis: Academic
Duration on-site: 10 months
Work Schedule: Mon-Fri. I also worked on public holidays and weekends a bit more flexibly.

(Biology)



Vivek Gurunath Sabarad

IISER Pune

" Experimental Quantum Kernels in NMR Applied to Machine Learning with Classical and Quantum Data "

Nature of Work: Theoretical -Experimental
Type of Thesis: Academic
Duration on-site: 10 months
Work Schedule: Not sure. It wasn't really fixed

(Physics)



Shashwati H

Ashoka University, Sonipat, Haryana

" Understanding Discrimination in Large Language Models "

Nature of Work: Computational -Experimental
Type of Thesis: Academic
Duration on-site: ~9 months
Work Schedule: Flexible as the work was computational

(HSS)



Utthara M Nair

IISER Pune

" Design of hybrid peptide foldamers as antimicrobial agents and Aβ aggregation inhibitors"

Nature of Work: Experimental
Type of Thesis: Academic
Duration on-site: 10 months
Work Schedule: I worked in the lab from Monday to Saturday, and occasionally on Sundays if there were pending tasks. Public holidays were also treated as regular working days.

(Chemistry)



Naman Pratap

International, University of Ottawa, Canada

" Iwasawa invariants of Mazur—Tate elements of elliptic curves and modular forms "

Nature of Work: Theoretical mostly, some 'numerical experiments' on SageMath
Type of Thesis: Academic
Duration on-site: My project was forced to be a remote one.
Work Schedule: Flexible as the work was computational

(Mathematics)

UYYASHRINILA P



What motivated you to pursue the research question addressed in your thesis?

My thesis primarily offers insights on the development of retinal ganglion cells (RGCs) through detailed characterization of the morphology and function of a particular RGC cluster- eomesa+ RGCs-in zebrafish. It also attempts to develop an understanding of how the transcriptomic, morphological and functional RGC types relate to one another.

Two main research interests for me have always been the visual system and neurodegeneration. A retinal degenerative disease called the retinitis pigmentosa runs in my family and currently, there is no definitive cure. Having closely witnessed the impact of such rare diseases on individuals, I believe that research on these diseases is necessary and wanted to take up one such research career in the future. I did internships and semester projects in labs that focus on neurodegeneration. However, for my thesis, I wanted to study the visual system mainly to learn more about it theoretically and experimentally. I was hoping that this combined experience would help me figure out if this field is truly the best fit for me. In addition to my long-term goals, I have also always had an intrinsic curiosity for answering questions in neuroscience- the emergent property conferred by the nervous system and the way it is achieved is quite fascinating to me. This interest aligned well with my research questions. So overall, I was pretty eager to work on my thesis.

Were you able to maintain focus on your original research question throughout the project? If not, what led you to diverge or shift focus?

Yes and no. While I continued to pursue my original research goal of cataloguing the morphology of eomesa+ RGCs in different developmental stages to understand how these RGC subtypes develop, my focus also shifted to understanding the functional role played by these RGCs. It had been previously shown by a lab member that eomesa+ RGCs are involved in phototaxis. I set out to understand which transcriptomic subtype of eomesa+ RGCs are relevant for phototaxis hoping to form a correlation between transcriptomic, morphological and functional RGC subtypes.

Some of the larval transcriptomic eomesa+ RGC subtypes are removed developmentally and we thought this could be related to the transition from photophilia to photophobia seen in zebrafish as they grow. At this time, I was already trying to map the eomesa+ transcriptomic types to morphotypes using in situ hybridization chain reactions (HCRs). So it was interesting to add the functional differences shown by these subtypes into the puzzle as well as it could explain the developmental patterns shown by this cluster more comprehensively.

Did you find yourself overanalyzing the data at any point? If yes, did you include those insights in your final thesis or treat them as side explorations?

All the time! My data showed that the morphological eomesa+ RGC subtypes innervated specific brain regions involved in non-image forming visual functions leaving us curious about their functional relevance. This led to the side exploration of phototactic abilities conferred by these subtypes. Apart from this, there were novel exciting observations I did not have time to fully explore. For example, an important eomesa+ RGC subtype was involved in phototaxis unexpectedly, most eomesa+ RGCs terminated in a region called the AF9 in the brain as opposed to 97% of the RGCs that terminated in the tectum, etc. I did add these insights to my final thesis.

How would you describe the work culture and environment at your host institute? In what ways did it differ from or resemble the culture at IISER Pune? How did this environment help or hinder your research experience?

The work environment in my lab was amazing. My PI, Prof. Dr. Herwig Baier, was very supportive throughout the thesis. My mentor, Dr. Eva Laurell, patiently trained me in all the experimental techniques I needed for my thesis and was always there to offer guidance. The other labmates were also very friendly and helpful. Honestly, the lab environment in MPI felt very similar to IISER Pune labs, which had positively impacted my research experience. The only difference I would say is the work culture over there- it is optional to work on weekends, public holidays or after 6 PM. But as a MS thesis student, you'd end up working anyways xD.

Had you previously worked or interned at this institute before starting your thesis? Were you recommended to this institute by a lab or mentor you had worked with previously?

No, I hadn't worked previously at MPI. I was given recommendation letters by mentors I had worked with previously.

Do you plan to continue working in the same field or topic as your thesis? Was this research area similar to or different from your previous work at IISER Pune or during other internships?

My thesis mainly involved imaging and behavioral analysis so technique-wise, it was similar to my previous projects- semester projects at Prof. Girish Ratnaparkhi's lab in IISER and summer project at Dr. Smitha Karunakaran's lab at CBR, IISc. However, the research field and model organisms were completely different. Currently, I am planning to shift back to studying neurodegenerative diseases for my PhD.

What are your future plans? Are you planning to pursue a PhD immediately, or take a break? Do you see yourself continuing in academia or exploring other career paths?

I have always wanted to be in academia long before I joined IISER so I do see myself continuing in it. I am planning to start my PhD around September in Deutsches Zentrum für Neurodegenerative Erkrankungen (DZNE), Martinsried.

Anything else you might want to add? Any message for your juniors?

For my juniors, I hope you all are having a wonderful time at IISER. I am sure I am not qualified enough to offer advice. But based on personal and peer experience, I think it is pretty important to figure out what truly interests you and more importantly, what does not interest you during BS-MS. Uncertainty is quite inevitable in the field of research. Sometimes, there are just too many variables beyond your control. Sometimes, despite your best efforts, the results can still be disappointing. I think having a sense of purpose- an understanding of why you are doing what you are doing- will help you tough it through! So, best of luck!

Thanks a lot to team Helicase for this opportunity to share my story, and to everyone who took the time to read it!

NAMAN PRATAP



What motivated you to pursue the research question addressed in your thesis?

By my third year at IISER, I had slowly honed in on number theory as the branch of mathematics I enjoyed the most, and it seemed to come more naturally to me than the other branches. In my third year (2023), I got the opportunity to work at the University of Ottawa, Canada, for a summer project under Prof. Antonio Lei. The project introduced me to elliptic curves, modular forms, L-functions, and p-adic analysis. So far, I had only learned number theory from the courses offered at IISER and hadn't done any semester projects on it since I was focusing on building prerequisites. The project with Prof Lei was the first time I actually worked on a research problem. We eventually gave up on it after numerous unsuccessful attempts during my three months in Ottawa. I found that tailoring my reading towards a specific goal was quite rewarding; it allowed me to get closer to contemporary research (although I am not fully there yet!) and gave me a lot of confidence in trying to read papers. When I came back for my 7th semester, I continued thinking about those objects I had read about. I also took up a semester project with Prof Kaneenika Sinha on an adjacent topic: "Modular forms". Over the second half of 2023, I grew more familiar with this area of research. This was my first genuine attempt at figuring out what might eventually become "my" area of research; gradually realising what parts of it excited me the most, and perhaps more importantly, what parts I did not see myself doing for a long time. I had kept in touch with Prof. Lei and frequently revisited some of the things I had tried during my summer project. During the same time, Prof. Lei put out a paper which, on the outset, was not related to the problem I worked on during the summer, but it did utilize the same objects and framework. The paper had recorded some behaviour of a class of elliptic curves based on some computations on SageMath, but was unable to prove it generally. I did some calculations of my own on SageMath and found that such behaviour could be seen in a much broader class of objects. When I reported these to Prof. Lei, his encouragement gave me a lot of confidence to pursue this question further. This is what I wrote about in the 'Project Proposal' we had to upload on SAM by January 2024. This was the starting point of the research question(s) that my thesis would eventually contribute to! The experience of working with these objects meant that I could focus almost entirely on the research problem during my fifth year (June 2024 onwards).

Very briefly: An elliptic curve is roughly a cubic polynomial in 2 variables, and a central problem in number theory and arithmetic geometry is to understand the structure of rational points on these curves. I studied what are called Mazur—Tate elements attached to elliptic curves. They are defined for a given elliptic curve E for each prime p, and their behaviour varies depending on how E looks when reduced mod p. This divides primes into various classes for a given E. There remained two classes of primes for which the behaviour of Mazur–Tate elements of elliptic curves was not well understood, and we were able to make progress on both those cases in my thesis!

Were you able to maintain focus on your original research question throughout the project? If not, what led you to diverge or shift focus?

I would say no, the initial problem seemed to rely on a property that wasn't known in the literature, and seemed to be out of reach. This was around June-July 2024. I did come up with a conjecture (a mathematical prediction) of my own based on some data, but we were quite skeptical of it and considered this a dead-end at the time. As time started to pass without any real progress, the desperation to get something original out of my work got stronger. I was definitely better versed with the theory by now, and I decided to work on another problem. This second problem was also an instance where some quite mysterious behaviour was seen computationally but there was no available explanation for it. This also had me running in circles for about 1-2 months until I made some progress, in a very special case. This was my very first theorem! (I vividly remember sending all my friends the Latex version of the statement with great excitement, around August-September 2024). This deviation actually wound up being one of the central themes of my thesis! That special case helped us get a hold of what was actually going on. We were able to generalise this relatively quickly- this is when I got to learn more about a millennium problem- the Birch and Swinnerton-Dyer conjecture! Our main theorem in this problem relies on understanding a particular term occurring in the statement of this conjecture- surprisingly enough, it also gave me a clue to my first problem, which was not at all directly linked to this!
(I will spare the reader the details, but feel free to contact me- I would happily yap about it to anyone interested!)

Did you find yourself overanalyzing the data at any point? If yes, did you include those insights in your final thesis or treat them as side explorations?

Oh yes, most definitely. Honestly, the idea of proving abstract results seemed extremely daunting to me. A lot of my work was motivated by first seeing certain behaviour 'in the wild'- by using Sagemath and some examples. I enjoyed having these prototypical examples as a scaffolding, which provided support for a more abstract exploration. Our instinct to look for patterns comes handy, although most of the time it can be quite misleading. Every so often there are some that actually seem to be true in generality- it gave me great hope whenever I saw such behaviour. The following is an instance of my "overanalysis" that led to a conjecture I made in July 2024 (and eventually a large part of it in November 2024 when I came back to it with added experience and intuition):
I was looking at say behaviour A of some objects E (and let p be a fixed number). For each E there is some rational number, say L, associated with each E and what I observed was that whenever E had the property A, the number L would have a p in the denominator! In a 2011 paper of my co-supervisor Prof. Robert Pollack, they saw behaviour A for a specific E and gave it as an example. The key was to try and generalise this behaviour A for all possible E, and the link seemed to be through this rational number L (which was not discussed in Prof. Pollack's paper). At first, we were quite skeptical and I chalked this up to just a coincidence- there didn't seem to be a direct relevance of this denominator to property A. I remember vividly when it all finally clicked, this was around October-November 2024. I had been reading through the example in Prof. Pollack's paper every day for almost two weeks straight, and I was on a walk with my dog Perry. The key was to restate property A and also to restate the existence of p in the denominator of L, both equivalent characterisations were then much easier to connect. What started as overanalysis ended up as an entire chapter of results in my thesis, and became the starting point of a paper.

How would you describe the work culture and environment at your host institute? In what ways did it differ from or resemble the culture at IISER Pune? How did this environment help or hinder your research experience?

Honestly, much of my daily work was solitary, so I cannot comment a lot on the "culture". Moreover, I was forced to do my project remotely due to visa issues (shout out to the Canadian embassy!). I'll talk a little bit about my experience with my supervisors instead. I had weekly meetings with my supervisors (I had two). Getting to work with multiple supervisors can be extremely fun and exciting - I had meetings every week, and some weeks the two meetings would build on each other, while in other weeks I was able to work on two different problems in parallel. This helped me keep moving when I inevitably got stuck! You get to hear different perspectives on the same topic/idea and how different people "do" math. I also realised how important it is to learn how to articulate and share your ideas (mathematical or otherwise) to different kinds of listeners, including people who are not fully familiar with your niche. Since all my projects have involved working solely with the supervisor, I don't think there are any huge differences- I have been fortunate enough to have had very supportive supervisors so far (both within IISER and outside). I want to use this opportunity to thank all of them: Prof. Supriya Pisolkar, Prof. Kaneenika Sinha, Prof. Antonio Lei, Prof. Baskar Balasubramanyam and Prof. Robert Pollack. I am extremely grateful to each of them for making me a better mathematician.

Had you previously worked or interned at this institute before starting your thesis? Were you recommended to this institute by a lab or mentor you had worked with previously?

Yes, as I mentioned earlier, I worked for three months at the University of Ottawa for a summer internship in 2023. I got this opportunity through the Mitacs Globalink Summer Program. Towards the end of my summer internship at Ottawa, my supervisor Prof. Lei suggested I could work with him for my thesis, and after coming back to IISER, I continued reading about the area of his research. I had really enjoyed my discussions with Prof. Lei, and I felt that I could have a good chance at producing some original results. During early 2024, there was growing political tension between India and Canada and anticipating issues with the visa, Prof. Lei and I decided to try to have a co-supervisor for my project to help with the regulations put in place by IISER regarding remote projects. He suggested I write to Prof. Robert Pollack (who was at Boston University at the time) who is an expert in the topics involved in my thesis. Prof Lei himself had referred to him when he was working on his PhD thesis! Prof. Pollack agreed to supervise me and I find myself extremely fortunate that I got to learn from his vast experience in the field.

Do you plan to continue working in the same field or topic as your thesis? Was this research area similar to or different from your previous work at IISER Pune or during other internships?

Yes, I do plan to do a PhD in algebraic number theory- but perhaps not necessarily in Iwasawa theory (my MS thesis topic)- rather in the overarching framework of what is called the Langlands program. This deals with vast generalisations of some objects that my thesis deals with namely, elliptic curves, modular forms, etc. Here is a broad strokes overview: On one hand, you have objects from geometry - say you want to know the rational points on a given algebraic curve- and on the other, you have some functions (called automorphic forms) coming from harmonic analysis. There is a precise one-to-one correspondence predicted between these two classes of objects (and this is almost always highly non-trivial to actually prove, even in special cases). These are roughly what make up the Langlands conjectures. There is a nice Quanta video on it (see also Frank Calegari's 30 years of modularity video for a slightly deeper dive). These correspondences can be seen via what are called L-functions. It turns out that values of these L functions (which are usually built from the Fourier expansions of the aforementioned automorphic forms) contain algebraic information about the geometric objects (like the rational points on curves I mentioned above). This in itself is also a huge area of research- Special values of L-functions. My thesis lies closer to this area, but I am eager to explore the general framework of the Langlands program. Previously, I have worked with Prof. Kaneenika Sinha on modular forms (these are the most well-studied class of automorphic forms), then I did a reading project on automorphic forms with Prof. Baskar Balasubramanyam- this was when I formally came across the Langlands program.

What are your future plans? Are you planning to pursue a PhD immediately, or take a break? Do you see yourself continuing in academia or exploring other career paths?

This year, I will be joining the Part III program at the University of Cambridge (this is a 9-month-long master's program), and I will be applying for PhDs this upcoming cycle. I would like to stay in academia and continue to do research in number theory. I would like to become a professor in India someday!

Anything else you might want to add? Any message for your juniors?

The past year has been a hell of a ride for me- from almost getting my MS project cancelled due to visa issues to getting this award- I am extremely fortunate to have such supportive supervisor(s) and friends. Talk to your supervisors and your friends regularly, especially when you feel lost. One piece of advice - try to 'clock in' and do a little bit every day- I am not saying anything new here - but what I've learnt from my short time as a theoretical researcher is that due to a lack of tangible milestones, one needs some form of self-discipline to sustain progress for a long period. This need not be a rigid routine; I have never been able to follow a daily routine. I tried to make sure I made some non-zero increment- either by reading some pages of a paper, or trying to prove an easy lemma on my own, etc. One "trick" that worked for me was to look at the known theorems and the assumptions in the papers related to my research problem and try to pinpoint where those assumptions are used in the proof. See if you can relax them, or alter them in a way, this often forces you to understand proofs/ideas from a first-principles point of view. Proving new theorems seemed almost impossible to me for my first 4 years at IISER. I've realised that every paper is, in a way, the authors taking the "natural" next step to extend what is known- you just need some experience to figure out what makes their steps "natural". Of course, some results will feel more innovative than the others, but this perspective definitely helps one better navigate contemporary research. I learned this way of viewing papers after seeing my supervisors trying to read papers for the first time. It was quite comforting to know that even people working for decades in the field can struggle with weird notation, implicit isomorphisms, too many lemmas between proofs, among other things. It also empowered me to realise that you definitely do not need to be a genius to come up with new theorems. Also, a shout out to math mimamsa (cause why not). Thank you to all the juniors who have ever heard me yap about math and to everyone who came to hear my maths club talk. If anyone is interested in my work, or in number theory in general, I would be happy to chat with them. A shameless self plug: The first few chapters of my thesis might be useful for students interested in what research in algebraic number theory might look like. I have tried to include all the references that helped me ease into this subject.
Thank you to Helicase for giving me this opportunity to share my journey!

VIVEK SABBARAD



What motivated you to pursue the research question addressed in your thesis?

My motivation to pursue the research question in my thesis evolved gradually over my time shaped significantly by my coursework and my semester projects. Initially, I was passionate about understanding the fundamental aspects of physics, hence I thought High Energy Physics would be the ideal for me. However, when I approached Dr. Sachin Jain in 5th semester for a project, I had to resort to working in open quantum systems since I lacked the mathematical skills and basics in QFT. But slowly I found myself deeply intrigued by quantum theory's intricate nuances.

Much of the literature that I pursued talked about the exciting research at the interface of quantum theory and computation which got me interested in the same. My coursework in Quantum Information and Computing deepened this interest. At the same time, I saw the growing impact of AI and machine learning on research. I strongly believe that staying aware of the evolving landscape of physics and its intersections with other fields is essential for any researcher. Motivated by this, I sought to build a solid foundation in these emerging areas, aiming to integrate them into my work or contribute to their advancement through a physics-driven perspective. Recognizing the limited formal coursework available at IISER on intersection of quantum computing and machine learning, I proactively engaged in self-study, completing certified online courses such as the Fundamentals of Artificial Intelligence through NPTEL.

This foundation proved critical for my MS thesis with Prof. T.S. Mahesh, where my work involved developing quantum kernel methods for machine learning tasks using liquid-state NMR. The possibility of applying machine learning techniques directly to quantum data, such as classifying quantum states or unitary transformations, provided a clear and compelling research question. Specifically, my thesis aimed to address the challenging problem of entanglement classification through quantum kernels, which presented both theoretical complexity and practical relevance.

Ultimately, the motivation behind my thesis was driven by the desire to explore and contribute to this emerging interdisciplinary area, leveraging quantum computing's unique capabilities to address problems inaccessible through classical methods.

Were you able to maintain focus on your original research question throughout the project? If not, what led you to diverge or shift focus?

Throughout my thesis project, while the core idea remained consistent - developing quantum kernel methods for machine learning tasks involving quantum data, there was indeed a significant shift in the practical approach due to experimental challenges. Initially, I intended to extend a quantum kernel method previously developed for classical data using solid-state NMR with adamantane, to handle quantum data. My numerical simulations showed promising results, achieving high accuracy in tasks like classifying entangled versus non-entangled states. However, during the experimental phase, we encountered a significant issue: the scalar coupling between the two qubits in each molecule turned out to be orders of magnitude weaker than the intermolecular dipolar interactions. This limitation made the time scales for encoding quantum states experimentally infeasible with solid-state NMR in plastic crystals, leading to a substantial setback.

Faced with this challenge, I pivoted my focus to liquid-state NMR, a more flexible platform for quantum computing experiments. Although this meant a change in the experimental medium, the core research objective—developing quantum kernels for quantum input data—remained unchanged. Adopting quantum registers with star topologies in liquid-state systems allowed me to continue effectively exploring the central research question. Eventually, this shift not only resolved the experimental hurdles but also resulted in successful demonstrations of quantum kernels handling quantum data with high accuracy.

This experience taught me that shifts in research focus, driven by practical constraints, are quite common. Adapting to these changes thoughtfully can still yield meaningful scientific insights.

Did you find yourself overanalyzing the data at any point? If yes, did you include those insights in your final thesis or treat them as side explorations?

I don't think I was overanalyzing the data at any point.

How would you describe the work culture and environment at your host institute? In what ways did it differ from or resemble the culture at IISER Pune? How did this environment help or hinder your research experience?

I completed my thesis at IISER Pune only. Over the time I have come to realize that the professor you work under will majorly determine what kind of work culture or environment you ger to work in. In my case, I worked with Prof. T S Mahesh and fortunately he was very nice. The PhDs in the group we also very helpful and overall group dynamics was great. I got to meet my supervisor almost every day because I was not working with any PhD, instead I was directly working with Prof. Mahesh. I had the freedom to work on any new direction that I thought would be worthwhile. There was good input from my PI in most of the discussions. Work culture was a bit unconventional for an experimental group. We did not have to do experiments all the time because a lot of our time went into simulating the experiments numerically and a bit of theoretical work. This meant we did not have fixed working hours. Sometimes I sat in from of my computer for 12 hours straight and sometimes I got away with working only for 10 hours a week. The progress we made and the results we showed are what mattered the most.

All in all, the environment was amazing and I think it contributed to my research experience positively. It helped me stay motivated throughout my thesis.

Had you previously worked or interned at this institute before starting your thesis? Were you recommended to this institute by a lab or mentor you had worked with previously?

Yes. I obviously worked in IISER Pune before I started my thesis.

Do you plan to continue working in the same field or topic as your thesis? Was this research area similar to or different from your previous work at IISER Pune or during other internships?

I plan to continue working in areas closely related to my thesis research, particularly quantum machine learning and quantum information science. Interestingly, this research area represented a shift from my earlier projects at IISER Pune. Initially, I worked extensively on theoretical projects in open quantum systems, exploring topics such as causality, thermodynamic stability, and non-Markovian dynamics. These earlier projects were largely theoretical, involving detailed analytical and numerical work without direct experimental implementation.

However, my thesis was fundamentally interdisciplinary, combining theoretical insights with extensive numerical simulations and experimental implementations. This transition required me to build skills in new areas, such as NMR spectroscopy and quantum algorithm implementation, significantly different from my previous theoretical focus. While challenging, this shift greatly expanded my scientific perspective and technical toolkit.

Thus, moving forward, I intend to build on these interdisciplinary experiences, focusing particularly on quantum computation and its intersection with machine learning, as I find it to be a vibrant and impactful research domain.

What are your future plans? Are you planning to pursue a PhD immediately, or take a break? Do you see yourself continuing in academia or exploring other career paths?

My immediate plan after graduation is to pursue a PhD, beginning from September 2025. I'll be joining the University of Vienna as a researcher on the project titled "Photonic Integrated Quantum Machine Learning (PIQLEARN)" under the supervision of Dr. Philip Walther at the Institute for Quantum Optics, Quantum Physics & Quantum Information. The project aligns closely with the work I conducted for my master's thesis, specifically focusing on quantum machine learning and quantum information.

Looking beyond my PhD, I'm currently inclined towards continuing in academia, as it would allow me to further explore and contribute to my research interests. However, I'm also open to exploring industry opportunities in quantum technology and quantum computing, especially roles that involve substantial research and innovation. This openness comes from recognizing that quantum information science is rapidly evolving, with academia and industry increasingly collaborating.

Anything else you might want to add? Any message for your juniors?

Research is often quite different from our initial expectations. It's full of uncertainties, unexpected challenges, and frequent revisions of plans. Rather than seeing these as setbacks, treat them as natural aspects of the scientific process. When you are stuck or unsure please don't hesitate to seek support from your mentors or supervisors. Often, fresh perspectives can provide solutions that might not be immediately obvious to you. Most importantly, always remember to maintain balance. Taking care of your mental and physical health is just as crucial as dedicating time to your research. Good luck, enjoy the journey, and make the most of your thesis experience!

SHASHWATI H



What motivated you to pursue the research question addressed in your thesis?
My research aimed to explore discrimination in large language models (LLMs) within the framework of economic games. For my Master's thesis, I was seeking a project at the intersection of economics and human behaviour, as studied in fields like social psychology. Given my prior experience with computational research, my supervisor encouraged me to pursue this particular question, which drew from the fields of economics, social psychology, and artificial intelligence.
We are currently at a stage where new models are being developed at a pace that far outstrips our ability to fully understand them. Investigating their behaviour in specific, nuanced contexts is essential to avoid overgeneralizing their capabilities. This is particularly relevant for the social sciences, where a reliable computational model of human behaviour has the potential to transform the way research is conducted. My project responds to this need, and that is what motivated me to pursue it.

Were you able to maintain focus on your original research question throughout the project? If not, what led you to diverge or shift focus?
Yes, my work revolved around the original research question.

Did you find yourself overanalyzing the data at any point? If yes, did you include those insights in your final thesis or treat them as side explorations?
Yes. I have been told that data analysis is more of an art than a science, and one of the key challenges is not getting lost in the myriad of tests that can be performed on a dataset. At one point during the project, I had compiled so many statistics and effect sizes from various analyses that I found myself thoroughly confused. This was partly due to the highly skewed distribution of data from these models, which made many commonly used tests inappropriate.
A general lesson I learned from this experience is the importance of clearly defining one's hypotheses and understanding the assumptions behind each test before conducting any analysis.
As for the second part of the question, yes, I did include those insights in the final thesis.

How would you describe the work culture and environment at your host institute? In what ways did it differ from or resemble the culture at IISER Pune? How did this environment help or hinder your research experience?
The work culture at Ashoka University is quite different from that at IISER Pune. The undergraduate pool at Ashoka places greater emphasis on application rather than research. Given that Economics is the largest department and a highly applied discipline, it naturally attracts many students who are inclined toward non-academic careers.
This environment helped me greatly. I was able to sit in on classes that deepened my interest in economics and finance, while also providing networking opportunities. Over time, I came to realise that I, too, am more drawn to the applied aspects of the field than to purely academic research.
Nevertheless, the professors and the Ashoka students who choose research are deeply passionate about their work and supportive, much like at IISER Pune, and this contributed positively to my research there.

Had you previously worked or interned at this institute before starting your thesis? Were you recommended to this institute by a lab or mentor you had worked with previously?
No, I had not interned at Ashoka University prior to starting my thesis. I wasn't recommended the university or my supervisor by anyone. While exploring institutes with good economics departments, I came across Ashoka University and decided to cold-mail my supervisor after finding that his line of work aligned with my interests.

Do you plan to continue working in the same field or topic as your thesis? Was this research area similar to or different from your previous work at IISER Pune or during other internships?
No, I do not plan to continue working on the specific topic of my thesis, nor do I intend to pursue a career in research. However, I do intend to remain in the broader field of economics, particularly from the more applied perspective of Business Administration.
The research area of my thesis was entirely different from my previous work at IISER Pune. I majored in Biology for my BS, and all of my semester projects were conducted in biology labs. I began with experimental work in Prof. Sutirth Dey's lab and later moved to Prof. Madhu's lab, where I spent the most time and gained experience in computational research. Shifting fields was a significant risk, but it was one I chose to take.

What are your future plans? Are you planning to pursue a PhD immediately, or take a break? Do you see yourself continuing in academia or exploring other career paths?
I plan on writing the CAT exam to pursue an MBA. I am interested in the intersection of economics and finance and I plan to move forward along a similar path.

Anything else you might want to add? Any message for your juniors?
Firstly, I took a path at IISER that is not commonly taken — shifting from biology (initially from experimental to computational work) to economics. Thanks to Dr. Bejoy's courses, I realized that I enjoyed economics more than biology, but that was also the extent of what I knew at the time. Many advised me against switching fields, saying it wasn't a wise decision. Looking back, it was one of the best decisions I've ever made. To all those who are (un)fortunate enough to not yet know what they want to pursue in their Master's, take that leap. A leap based on calculated risk. Believe in yourself, and others will eventually learn to believe in your decisions too.
Secondly, we often hear about the trade-off between specializing in a single field and exploring multiple fields. There are pros and cons to both, and I've come to realize that there is no single right answer. This, in fact, is reassuring — because it means there is no one fixed way to reach where you want to be. Chart your own unique path toward finding something you truly enjoy doing, and as Steve Jobs said, "You can't connect the dots looking forward; you can only connect them looking backwards."

UTHARA NAIR



What motivated you to pursue the research question addressed in your thesis?
My thesis was motivated by the growing need for effective strategies against Alzheimer's disease, which is not just a clinical, but also a huge emotional and financial burden on patients and their families. This inspired me to work on Aβ aggregation inhibitors.
I also developed a strong interest in peptide chemistry after joining the H. N. Gopi lab at IISER Pune. The idea that specific peptide sequences could be designed to perform diverse and targeted biological functions made this project both exciting and meaningful for me.

Were you able to maintain focus on your original research question throughout the project? If not, what led you to diverge or shift focus?
Yes, I was able to maintain focus on the original research question throughout my MS project fortunately. The initial phase of my work, leading up to the mid-year evaluation, was dedicated primarily to the synthesis of our designed peptides. In the second phase, we transitioned into biological studies to evaluate their activity, staying aligned with our goal of exploring Aβ aggregation inhibition and the antimicrobial activity of our peptides.

Did you find yourself overanalyzing the data at any point? If yes, did you include those insights in your final thesis or treat them as side explorations?
There were moments when I found myself overanalyzing the data, particularly during the interpretation of peptide-Cu^{2+} interactions. I was fascinated by the multiple potential binding modes of metal ions to our peptide and their possible influence on aggregation pathways. At points where I felt uncertain or confused, I dug deeper into the literature to better understand the underlying mechanisms. The insights that emerged from this exploration helped shape my interpretation, and although not all of them made it into the main body of the thesis, some were briefly mentioned in the introduction or discussed as potential avenues for future work.

How would you describe the work culture and environment at your host institute? In what ways did it differ from or resemble the culture at IISER Pune? How did this environment help or hinder your research experience?
Since my research experience has been solely at IISER Pune, I don't have a direct basis for comparison with other institutes. That said, the work culture at IISER Pune was both rigorous and supportive. While the environment was certainly demanding in terms of expectations and workload, it also provided ample resources, guidance, and academic freedom to carry out my research effectively.

Had you previously worked or interned at this institute before starting your thesis? Were you recommended to this institute by a lab or mentor you had worked with previously?
I had worked in Prof. H. N. Gopi's lab for two semesters before continuing there for my MS thesis. I initially joined the lab in my third year, after thoroughly enjoying a course taught by Prof. Gopi. Having already spent considerable time in the lab, I was used to the work culture and routine, which helped me adapt quickly and maintain the pace required for the thesis work.

Do you plan to continue working in the same field or topic as your thesis? Was this research area similar to or different from your previous work at IISER Pune or during other internships?
Sure, I'm planning to continue working in peptide chemistry. Back in my second year at IISER Pune, I was actually quite confused about whether to major in chemistry or biology. So, I explored both by doing internships and projects in areas like cancer biology and biochemistry. Eventually, I found myself drawn to chemical biology, and that's how I ended up in Prof. H. N. Gopi's lab. Working on peptide chemistry there really clicked with me, and that's the direction I'd like to keep pursuing.

What are your future plans? Are you planning to pursue a PhD immediately, or take a break? Do you see yourself continuing in academia or exploring other career paths?
I'm planning to pursue a PhD soon, but I'm taking it slow for now by exploring open positions and potential funding opportunities. While I'm quite sure I want to stay close to science in whatever I do, I'm still figuring out whether academia is the right long-term path for me. I'd like to stay open to different possibilities and see where science takes me during and after my PhD.

Anything else you might want to add? Any message for your juniors?
Don't get too overwhelmed by the MS thesis. It's not just a final requirement, but a valuable opportunity to learn, grow, and experience the research process in depth. Try to understand the relevance of every step you take in the lab, even if it seems small or routine. Not every day will be productive, and that's okay. What matters most is showing up, and being present in the process.

ARNAB CHAKRABORTY



What were the key motivations or gaps in the field that led you to pursue your PhD thesis topic?

Lysophosphatidylserine (lyso-PS) is a signaling lipid with implications in diseases, and while it is well studied in the context of the nervous and immune systems, very little was known about its metabolism in other peripheral tissues. Hence, we set out to study metabolic pathways of lyso-PS in these less explored tissues.

How did your research question evolve over the course of your PhD? Were there significant deviations from your original plan?

To address the major research question, we identified an enzyme capable of hydrolysing lyso-PS in the liver and kidney by the time I completed the fourth year of my PhD. Hence, we decided to add another side-project involving further characterization of another enzyme - ABHD12, which is implicated in the neurodegenerative disorder PHARC (polyneuropathy, hearing loss, ataxia, retinitis pigmentosa, and cataract).

Describe the methodology you used. What were the major challenges you faced in implementing it, and how did you overcome them?

Broadly, we used a combination of activity-based protein profiling, in-vitro substrate hydrolysis assays and different mass spectrometry methods to delineate these pathways. During the course of both these studies, we developed several biochemical and cellular assays to study the activity of these enzymes in vivo and understand their substrate preferences. To complement all these biochemical and cell biological studies, we also performed extensive LC-MS based lipidomics in conjunction with knockout mice models, when possible, to study both these enzymes. The major technical challenge was development of a substrate hydrolysis assay to accurately quantify lipid hydrolysis products by LC-MS in a high throughput manner. Gradually, we optimized experimental conditions and mass-spectrometry parameters to devise an assay that accurately gave a readout of substrate hydrolysis rate.

How do your findings contribute to the existing body of knowledge in your field?

We biochemically characterized the integral membrane enzyme ABHD12 (major lyso-PS degradative enzyme) from the serine hydrolase family, and our research has provided new insights into the role that this lipase plays in the progression and pathology associated with the human neurological disorder PHARC.
Besides this, we discovered that another lipase, ABHD6, also functions as a major lyso-PS degrading enzyme in the mammalian liver and kidneys, and showed using cellular and mice models that depleting this enzyme's activity results in dysregulated lyso-PS metabolism in these tissues.

Did your work result in publications, presentations, or collaborations? How did these contribute to your academic development?

The body of work performed during my PhD yielded in >10 publications, including two first author papers in J. Biological Chemistry and Biochemistry, and an exhaustive review (with Siddhesh) in Chemical Reviews, besides other collaborative publications in eLife (x2 papers), Angewandte Chemie, Redox Biology, iScience, J. Biological Chemistry, Biochemistry. I also got a chance to present my research at the first Lipidomics Gordon Research Conference (GRC) in Italy in 2024, funded by the Infosys Travel Award and GRC. These opportunities have helped me explore a wide variety of scientific projects(collaborations) and have honed my writing and presentation skills over time.

How would you describe the research culture at your institute? What aspects helped or hindered your progress?

IISER Pune fosters a collaborative environment with its shared lab system and the Department of Biology facilitates a smooth research experience. Right from borrowing a common chemical, to following up on due orders, to eventually getting trained towards using new instruments, the institute and department have been instrumental in the completion of my PhD journey.

7. Did you engage in interdisciplinary work or collaborations beyond your primary research group or department?

Yes, as described before, I had the opportunity to develop multiple LC-MS methods for the detection of lipids and metabolites in different biological systems for various collaborative projects across the country.

8. In what ways has your PhD research influenced your long-term academic or professional goals?

I joined this PhD programme to further pursue a career in academia, and I am still inclined to follow the same direction six years later.

9. What are your immediate plans post-PhD (e.g., postdoc, industry, teaching)? How do these align with your research interests and skills?

I am applying for postdoctoral positions in different laboratories across the world that work on studying lipid metabolism in the context of human disorders. This is because I now want to apply my skills in lipid biochemistry and mass spectrometry to further study human diseases.

10. If you had the opportunity to redo your PhD journey, what would you approach differently and why?

I believe that everything happens for a reason, and despite the challenges and lows encountered, I would want my PhD journey to be exactly the same. Each roadblock has taught me how to overcome different challenges, and I am stronger and more well equipped to take on the next research problem now.

11. Anything else that you would like to share? Any message?

Solving a biological problem is tough and tedious. The only way to give one's best in the laboratory is just to show up again and again despite the challenges. I think it is important to have a balanced lifestyle so that we can proactively think about our research each day and to always reset after academic failures.
A wave always has crests and troughs, but it is important that it keeps moving on.

SAJID SAIKIA



What were the key motivations or gaps in the field that led you to pursue your PhD thesis topic?

There is a growing demand for short-wave infrared (SWIR, 700–1700 nm) emitters due to their wide-ranging applications in bio-imaging, security surveillance, food inspection, remote sensing, and optical fiber communication. However, existing SWIR light-emitting diodes(LEDs) technologies largely rely on epitaxially grown III–V semiconductors, which are expensive and difficult to scale for mass production. This presents a significant gap in the development of cost-effective and scalable SWIR emitters especially broadband ones. Motivated by this challenge, my Ph.D. research focused on designing broadband SWIR-emitting materials by doping metal halide double perovskites. Alongside material design, my work also emphasized understanding their fundamental photophysics and demonstrating practical potential through the fabrication of phosphor-converted LEDs (pc-LEDs).

How did your research question evolve over the course of your PhD? Were there significant deviations from your original plan?

At the beginning of my PhD, my research was primarily focused on rare-earth-based SWIR emitters, guided by gaps that I could identify in the existing literature. However, as I gained deeper material and spectroscopic insights, my approach evolved significantly. I broadened the scope to include transition metal doped systems, which offered the possibility of achieving unprecedented broadband SWIR emitters. This shift allowed me to explore structure property relationships and their impact on luminescence properties. Later on, I explored fabrication of pc-LED and their performance which I never planned at the beginning. Additionally, my growing interest in the fundamental photophysics of these materials led me to investigate temperature-dependent behaviours and excited-state dynamics, which provided critical insights into their luminescence mechanisms.

Describe the methodology you used. What were the major challenges you faced in implementing it, and how did you overcome them?

To design suitable materials for SWIR emitters, I employed a range of synthesis techniques, including solution-based hydrothermal methods, solid-state reactions for bulk crystal growth, and hot-injection techniques for nanocrystals. These were followed by detail material characterizations and photoluminescence spectroscopy, including temperature-dependent studies. Finally, I fabricated and measured phosphor-converted LED (pc-LED) devices. One significant challenge I encountered was during the synthesis of a particular material via a solution-based route, which repeatedly failed despite multiple attempts. After optimization of various parameters, I realized that the material could instead be successfully synthesized at high temperature using a solid-state method. Careful control of precursor chemistry and reaction conditions ultimately enabled me to design the desired material. I was particularly curious to probe the local environment (meaning: just a few angstroms around) of the dopant in my material, which required synchrotron-based EXAFS (Extended X-ray Absorption Fine Structure) measurements. Accessing such a facility was a challenge in itself. My supervisor and I successfully secured funding under the DST-DESY program, which allowed us to perform the experiments at PETRA-III in Germany. We later collaborated with experts to interpret the EXAFS data, which was challenging at the same time interesting and rewarding experience.

4. How do your findings contribute to the existing body of knowledge in your field?

My research contributes to the field by introducing novel design strategies for both ultrabroadband and sharp SWIR emitters using environmentally benign and stable halide double perovskites. It includes the concept to generalise sensitization of lanthanide (f–f) with antimony ion. Further for the first time we developed, ultra broadband emitters by using transition metal (d–d) emissions. A key finding was the ability to tune the crystal field environment to control emission properties, enabling the design of dual emitters. Additionally, I fabricated pc-LED prototypes and demonstrated their application in food freshness detection, thereby tried to bridge fundamental photophysics with real-world SWIR based applications.

5. Did your work result in publications, presentations, or collaborations? How did these contribute to your academic development?

Yes, my PhD work has resulted in multiple research publications, including two VIP articles in Angewandte Chemie, which significantly contributed to the visibility of our research. I presented my findings at several national and international conferences, including talks at Nano Ge EMLEM 2023 and MATSUS 2024. My work was also showcased through highlighted posters at the Prime Minister's Research Fellowship (PMRF) annual meetings in both 2023 and 2024, along with several international conferences. These opportunities led to multiple recognitions, including best oral and poster presentation awards, a granted patent, and even a media highlight in The Times of India.

Collaboratively, I worked with several prominent research groups across India including IISER Bhopal, NCL Pune, and CeNS Bangalore. These interdisciplinary collaborations allowed me to extend my expertise beyond the core focus of my lab, particularly in structural and photophysical understanding. They also played a pivotal role in sharpening my scientific communication skills, cultivating critical thinking, and deepening my understanding of the broader materials design.

How would you describe the research culture at your institute? What aspects helped or hindered your progress?

The research culture at IISER Pune is intellectually stimulating, with a vibrant community of scholars fostering thought provoking discussions through regular seminars and in house conferences. The institute promotes strong interdisciplinary collaboration and provides access to necessary research facilities, which significantly supported my work. Constructive mentorship, group discussions and a collaborative peer environment were key strengths that enhanced my research experience. While occasional equipment downtime, particularly the unfortunate fire incident in the chemistry building did pose challenges, we learned to manage these effectively through careful planning and adaptability.

Did you engage in interdisciplinary work or collaborations beyond your primary research group or department?

Yes, I actively engaged in interdisciplinary collaborations beyond my primary research group. I collaborated with Dr. Surajit Saha's group in the Department of Physics at IISER Bhopal and Dr. Kadhiravan's group at NCL Pune in the Polymer Science and Engineering Division. Additionally, I worked with beamline scientist during EXAFS measurements and with Mr. Rohit, an engineer in an industry, to gain practical insights into pc-LED fabrication. These interdisciplinary interactions significantly broadened the scope and impact of my research, enabling me to approach problems from multiple perspectives.

In what ways has your PhD research influenced your long-term academic or professional goals?

Over the course of my Ph.D., my perspective on research has evolved and deepened, solidifying my commitment to a long-term career in science. It has taught me to remain open to diverse ideas and interdisciplinary topics beyond my core expertise. I'm particularly interested in pursuing research at the interface of chemistry, focusing on luminescent and magneto-optic materials. My work has also shaped a strong interest in translational science that bridges material design chemistry towards real-world applications.

What are your immediate plans post-PhD? How do these align with your research interests and skills?

I have recently started a postdoctoral position at the University of Ottawa, where I am exploring luminescent materials with the aim of extending this work to molecular systems exhibiting magneto-optical functionalities, particularly in the design of single-molecule magnets. This opportunity builds directly on my expertise in spectroscopy and material design. The transition aligns strongly with my long-term goal of contributing to the development of multifunctional optoelectronic and magneto-optic systems that integrate fundamental photophysics with advanced material functionalities.

If you had the opportunity to redo your PhD journey, what would you approach differently and why?

If I had the opportunity to revisit my Ph.D. journey, I would aim to complete certain phases of the work more efficiently. In particular, I would integrate the device fabrication especially the pc-LED component earlier in the process. Introducing this aspect sooner would have helped me better to connect material properties of pc-LED with real-world performance, offering deeper insights into technological relevance of device applications.

Anything else that you would like to share? Any message?

During my Ph.D., I learned that persistence, curiosity, and staying humble really matter. Don'tbe afraid to ask questions, no matter how basic they seem, and be open to learning fromeveryone around you. Research is not just about working alone it grows through teamwork and sharing ideas. As my supervisor, Prof. Angshuman Nag, often said: "If you can express your research finding in one or two sentences, that's quality research." I've come to truly believe in that, and I pass it on to my younger Ph.D. friends.

AJINKYA GAIKWAD



What were the key motivations or gaps in the field that led you to pursue your PhD thesis topic?

While pursuing my BS-MS and PhD coursework, I found Graph Theory and Algorithms to be particularly fascinating subjects. The structural richness of graphs makes them a powerful tool for modeling a wide range of real-world problems as computational ones. Given their widespread applications, developing efficient algorithms for graph problems is not only intellectually rewarding but also practically important.
During this time, I also undertook a reading project in the field of Parameterized Complexity Theory. This area offers a compelling framework for tackling computationally hard problems, especially those that are intractable under the widely believed assumption that P/= NP. The project helped me gain a deeper understanding of advanced algorithmic techniques, along with their strengths and limitations.
Motivated by my growing interest in these areas, I approached Prof. Soumen Maity to discuss potential topics for my PhD dissertation. We decided to study a range of graph- theoretic computational problems that are both theoretically rich and have practical significance. While some of these problems had been explored in the parameterized complexity literature, many important questions remained open. The challenge and potential impact of resolving these questions strongly appealed to me, and that's how I decided to pursue this line of research for my PhD.

How did your research question evolve over the course of your PhD? Were there significant deviations from your original plan?

At the start of my PhD, we had identified a few graph-theoretic problems to work on. Most of the open questions related to these problems were resolved within the first two years of my research. This initial work led to publications in reputable conferences and helped build my confidence to tackle more ambitious problems with the potential for top-tier publications.
A turning point in my research journey came when my supervisor introduced me to Prof. Saket Saurabh, a leading expert in Parameterized Complexity Theory. Saket had a significant influence on my research thinking. Through regular discussions with him and my supervisor, I gradually developed a better understanding of what makes a research problem truly impactful. I came to appreciate that choosing the right problem is just as crucial as solving it—this insight played a major role in shaping the later stages of my PhD.
As my PhD progressed, I became more deliberate in selecting research directions, focusing on problems that were both technically challenging and theoretically meaningful. This shift in approach led to results that were published in top conferences, marking an important evolution from where I had begun.

Describe the methodology you used. What were the major challenges you faced in implementing it, and how did you overcome them?

My research primarily relied on a range of algorithmic techniques from the field of Parameterized Complexity, many of which I was introduced to during my initial reading project. These included methods such as kernelization, bounded search trees, iterative compression, color coding, dynamic programming, and proving lower bounds under various complexity-theoretic hypotheses.
While these techniques are powerful, they are often not directly applicable to interesting and non-trivial research problems in their standard form. One of the key challenges was learning how to apply these tools creatively and adapt them to the specific structural properties of the problems I was studying. This required going beyond textbook applications and developing a deeper, more nuanced understanding of these methods.
To overcome these challenges, I made it a point to regularly read recent research papers in the field and engage in discussions with other researchers. Interacting with Experts, attending seminars and talks, and staying connected to ongoing research helped me gain new perspectives and ideas. These interactions often led to a better conceptual grasp of existing techniques and inspired novel ways to use them in my work. This process of continuous learning and collaboration played a crucial role in addressing themethodological difficulties I faced during my PhD.

How do your findings contribute to the existing body of knowledge in your field?

One of the key contributions of my PhD research was proving the existence of fixed-parameter tractable (FPT) algorithms for the maximum minimal variants of well-known problems such as the Minimum st-Cut and Odd Cycle Transversal. These problems had been posed as open questions in the literature, and resolving them helped advance our understanding of the parameterized complexity of such variants.
The abstract techniques developed in the course of this work also allowed us to tackle natural generalizations of these problems, demonstrating the broader applicability of our methods. In addition to algorithmic results, we established several hardness results that rule out the existence of FPT algorithms under standard complexity assumptions. These findings help delineate the boundary between tractable and intractable cases in a more refined way.
Some of the problems we studied are motivated by applications in modeling cooperative and competitive dynamics in networks, as well as in epidemiology. Our results contribute to a deeper understanding of the computational complexity underlying suchmodels, bridging theoretical insights with practical relevance.

Did your work result in publications, presentations, or collaborations? How did these contribute to your academic development?

Yes, my research resulted in several publications, some of which were presented at in ternational conferences. Attending these conferences was a highly rewarding experience.
It gave me the opportunity to present my work to a broader audience, receive valuable feedback, and engage in discussions with researchers working on related topics. These interactions not only deepened my understanding of the field but also helped
me stay up to date with the latest developments. Being part of the wider research community allowed me to appreciate different perspectives and approaches, which in turn shaped how I thought about problems and solutions. Overall, the experience of publishing and presenting my work significantly contributed to my academic growth and confidence as an independent researcher.

How would you describe the research culture at your institute? What aspects helped or hindered your progress?

I believe that the Department of Mathematics at IISER Pune provides an excellent environment for pursuing research. The institute offers access to a wide range of international conference proceedings and journals, which has been extremely valuable for staying current with developments in my field.
IISER Pune also actively encourages academic visits and collaborations with other institutes, which has been an important and enriching part of my research journey. The administrative support for such academic activities is well-managed and efficient, allowing researchers to focus more on their work rather than logistical challenges.
One area where I feel the research culture could be further strengthened is in promoting more interdisciplinary collaborations across departments. Encouraging such interactions could lead to research that has broader applications and fosters innovation at the intersection of different scientific fields.

Did you engage in interdisciplinary work or collaborations beyond your primary research group or department?

While I did not engage in interdisciplinary work during my PhD, I did collaborate with researchers from other institutes. These collaborations provided valuable perspectives and helped strengthen the quality of the research. Working with experts outside my immediate research group allowed me to learn new approaches and refine my problem-solving skills.

In what ways has your PhD research influenced your long-term academic or professional goals?

My PhD experience has strongly reinforced my desire to continue doing research in the future. Working on challenging problems and contributing to the field of theoretical computer science—particularly in parameterized complexity—has been deeply fulfilling, and I hope to remain active in research through an academic or research-oriented position.
Another important aspect of my PhD journey was teaching. I served as a teaching assistant for several courses at IISER Pune and also had the opportunity to teach parts of courses outside the institute. These experiences significantly improved my communication and teaching skills and helped me understand how to explain complex ideas effectively. I now view teaching as a natural complement to research, and I look forward to continuing both in my future academic career.

What are your immediate plans post-PhD (e.g., postdoc, industry, teaching)? How do these align with your research interests and skills?

I am currently in the process of applying for postdoctoral positions. My goal is to continue conducting research in theoretical computer science, particularly in the areas of parameterized complexity and graph algorithms, which closely align with my PhD work. A postdoc position will allow me to further develop my research skills, explore new problem areas, and collaborate with experts in the field.
Given my background and interests, a postdoctoral role is a natural next step that will help me deepen my expertise and prepare for a long-term academic or research-oriented career.

If you had the opportunity to redo your PhD journey, what would you approach differently and why?

If I had the opportunity to redo my PhD journey, I would make a more conscious effort to attend more conferences and workshops early on. These events provide an excellent platform to interact with researchers, learn about ongoing work in the field, and gain valuable feedback on one's own research.
I also wish I had given more regular talks during the early stages of my PhD. Pre senting ideas, even informal ones, helps clarify one's own understanding and opens the door for useful suggestions and collaborations. Engaging more actively with the broader research community from the beginning would have helped me grow faster as a researcher and gain confidence in discussing and presenting my work.

Anything else that you would like to share? Any message?

Enjoy your research journey and try to find joy in the day-to-day process of doing research. Progress may feel slow at times, but consistent effort and curiosity go a long way in shaping you as a researcher.
Also, take care of your mental and physical well-being—it's just as important as academic success. Lastly, while striving for your own growth, don't forget to support and uplift those around you. A positive and collaborative environment benefits everyone.

GOKUL M A



What were the key motivations or gaps in the field that led you to pursue your PhD thesis topic?

Initially, I was drawn to materials suited for optoelectronic applications such as solar cells, LEDs, and photodiodes. Although I didn't have prior research experience, I was motivated by the potential of contributing to energy-related technologies. After discussions with my advisor, Dr. Atikur Rahman, we decided to explore lead halide perovskites, which had gained significant attention in the research community due to their promising optoelectronic properties. The idea was to study these materials by fabricating devices at the nano/microscale to gain deeper insights into their behavior. It seemed like a timely and challenging direction, with a lot of room for research.

How did your research question evolve over the course of your PhD? Were there significant deviations from your original plan?

Our lab was newly established, and we had to build much of the infrastructure from scratch, which gave me an exciting opportunity to work hands-on with instrumentation. My advisor gave me the freedom to explore various directions, which made the process both enjoyable and intellectually enriching. While the core focus remained on perovskites, I developed a strong interest in 2D materials, especially for constructing heterojunctions with perovskites. This interest naturally extended our research scope. So, rather than a deviation, it was more of an organic evolution—from studying perovskites in isolation to integrating them with 2D semiconductors for device applications.

Describe the methodology you used. What were the major challenges you faced in implementing it, and how did you overcome them?

Various techniques were used to grow semiconductors and fabricate devices out of them. We used low-temperature solution growth techniques for synthesizing perovskite crystals and chemical vapor deposition (CVD) for growing monolayer transition metal dichalcogenides (TMDs). Initially, growing uniform monolayer TMDs was a major challenge due to the large parameter space involved. My labmate, Dr. Vrinda Narayanan, and I worked together to optimize these growths, eventually achieving better crystal quality.
For perovskites, understanding their crystal growth dynamics led us to develop novel growth approaches. Fabricating devices was another challenge—perovskite crystals were small and fragile, and traditional techniques didn't always work. We adopted workarounds like sacrificial layers for device transfer. Fabricating flexible devices brought its own challenges, which I tackled while working with Dr. Divya Nechiyil. Lastly, building heterostructures required developing a delicate manual transfer technique that is still being refined. Overall, the process was iterative and hands-on, requiring persistence and innovation.

How do your findings contribute to the existing body of knowledge in your field?

Well the field is vast and I would say my contribution to the field is miniscule. I think its too early to say if any of this would have a significant impact on the field in general. It is not everyday that a ground breaking work could happen. The most significant contribution in my opinion is that we were able to grow some ferroelectric CsPbBr3 crystals. This was something that may hold some meaning but only time would tell.

Did your work result in publications, presentations, or collaborations? How did these contribute to your academic development?

Yes, my work did result in publication, presentation and collaborations. Writing scientific publications was a different experience and it took me some time to understand how to present and showcase your work. Presentation is very important as it could severely undermine the value of your work if not done right. Presentations are also important as it challenges you to concisely present your work in a very digestible manner to the audience. Most work that I did was possible because I had good collaborators. For example people from Dr. PavanKumar's lab has helped us a lot. And I believe that it makes it more efficient to collaborate with people who are masters of their work to make sure that the project succeeds, rather than you trying to do everything ourselves. Being a master takes time and effort, so it's best to let professionals handle parts in which you don't have expertise on to keep the process more efficient and the work more robust.

How would you describe the research culture at your institute? What aspects helped or hindered your progress?

The general research culture at IISER is good and it varies from lab to lab. The research culture at iiser is good especially for BS-MS students, as you guys get a taste of being a researcher even before graduating. For PhD students it is the work culture of the lab that matters more for their work and the research culture of the institute facilitates collaboration and interdisciplinary work. My PI gave me a lot of freedom to try different things and I believe that helped a lot in my research

Did you engage in interdisciplinary work or collaborations beyond your primary research group or department?

Of course. I think most of the work is interdisciplinary. We use different methods and approaches to solve or understand a problem and most works are thus interdisciplinary in that sense. I have worked with Dr. Shailendra kumar, a good friend from Dr. Pavankumars lab, who works on plasmonics and our group has worked with Dr. Angshuman Nags lab at IISER.

In what ways has your PhD research influenced your long-term academic or professional goals?

PhD is more like a training period. It helps you develop skills like problem solving, planning, risk evaluation and mitigation, and many other soft skills which are more valuable than the niche skills you get from your project. It's the process that is more valuable than the project itself. In research the project might succeed or fail and it is your ability to keep a positive outlook and decision making as to when to proceed and when to seek a different path when faced with problems that are developed and this can be applied everywhere and not just on a particular topic. So, I would say that my PhD has given me something that influences me as a person and not just my long-term goal or professional goal. Research should make you more open minded and also capable of making quick decisions. The research in itself helped me realise the huge barriers in technological advancement and by seeing how far we have came it seems like magic

What are your immediate plans post-PhD (e.g., postdoc, industry, teaching)? How do these align with your research interests and skills?

I was doing a postdoc at USC and have now transitioned into the semiconductor industry. My PI often said that experiencing the research culture in the US is essential—and I am glad I did. Now, I have decided to explore the industrial side. I just joined LAM Research in Bangalore to pursue a career at the core of the semiconductor industry. Both positions are very much related to semiconductors, which is my core area of interest. The more you know about the semiconductor industry the more you realize just how magical the processes involved in making semiconductor chips truly is. I am looking forward to being a part of a community that helps make our digital world faster, smarter and greener.

If you had the opportunity to redo your PhD journey, what would you approach differently and why?

There are a lot of things that I would approach differently as they were not the best decision, but I had fun doing the things that might be considered a not so productive way. So I am not sure, it is better for your career to be focused but then you don't explore enough. I would do everything differently as in I will explore different things and yes, my approach to publishing or record keeping would be drastically different from what I did during the initial days of my PhD. Another thing would be to look for internship opportunities which could be beneficial. I would think of networking more, it is still not something that I do enough of. We are here because of how we are connected, not just to people around us but also to the people before us.

Anything else that you would like to share? Any message?

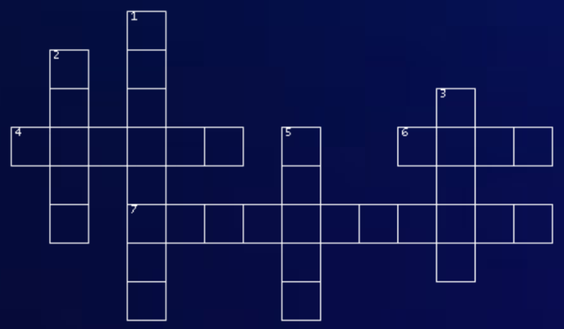
PhD is journey You get to learn and take a lot more from it than just your research

fun and games

Chess | Crosswords

#TANGLED TUESDAYS

“¬(x ∈ x) ⇒ Tangled Truths”



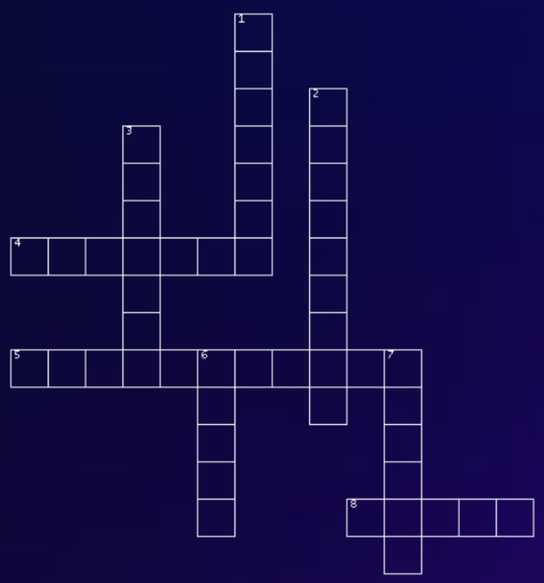
Across

4. The hidden core of a function, not the popcorn kind.
6. A circle forged from closure, held together by associative gravity and a missing multiplicative heir. Two operations enter; only structure remains.
7. Two universes whisper the same story in different dialects; only the mapmaker sees no difference. Distinct, but indistinguishable.

Down

1. A ghost who touches everything but leaves no trace. Neither participant nor stranger. The zero of transformation, the one of presence.
2. A loyal shadow that consumes multiplication like prophecy, closed off like a monastery, yet expanding like ambition within a ringed fortress.
3. The destination no traveler reaches, but toward which every step leans with infinite longing.
5. Dr. Frank is learning theory of a collection of people, he is learning_____

“Cursed Bones”

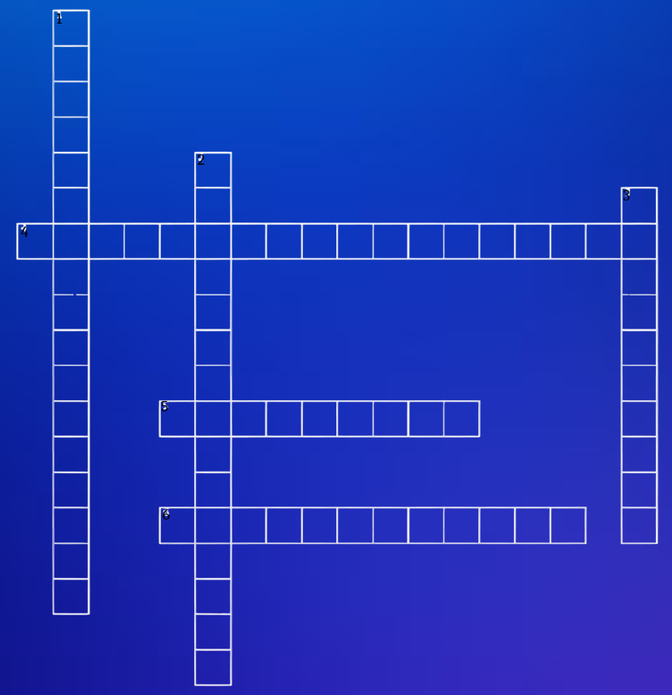


Across

4. Technically in your arm, spiritually in your stand-up routine. Sounds like it gets the joke.
5. The middle managers of your hand, not fingers, not palm, just there doing all the real work.
8. A bone that thinks highly of itself, supports everything and still manages to look down on the tibia.

Down

1. Seven reasons Michael Jackson could moonwalk. Tiny but talented.
2. The part of your skull that watches your back, even though it can’t see a thing.
3. Kneecap? No cap. Just vibes, cartilage, and occasionally... existential clicking sounds.
6. Named after a titan, cursed with neck pain. Holds your head high whether you're confident or just faking it.
7. The only bone that could fit through its own name. Smallest in the class, loudest in the ear.



“Lab Instruments”

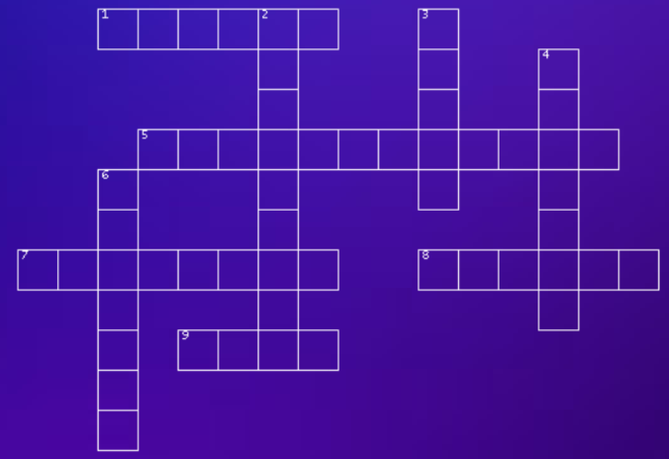
Across

4. (2 words, no space) I look at different sections till I find the sharpest signals. Subtle flex, I am an amazing photographer!
5. My shrill cries are enough to break your cells down.
6. I go really hot, slightly cooler, hot again, several times till I go really cold, forever.

Down

1. Your best friend while performing a Bradford's Assay!
2. (2 words, no space) I shake, shake, shake and make your cultures bloom!
3. RPM tells how fast I move, but RCF tells the force I throw!

“Lights, Camera, ...Collapse🎬”



Across

1. Red makes you wake. Blue makes you late.
5. Love, dust, and a fifth dimension in Morse.
7. “Once upon a time, 150 million years ago ...”
8. Unobtanium? Try empathy, painted blue.
9. Fear is the plot killer.

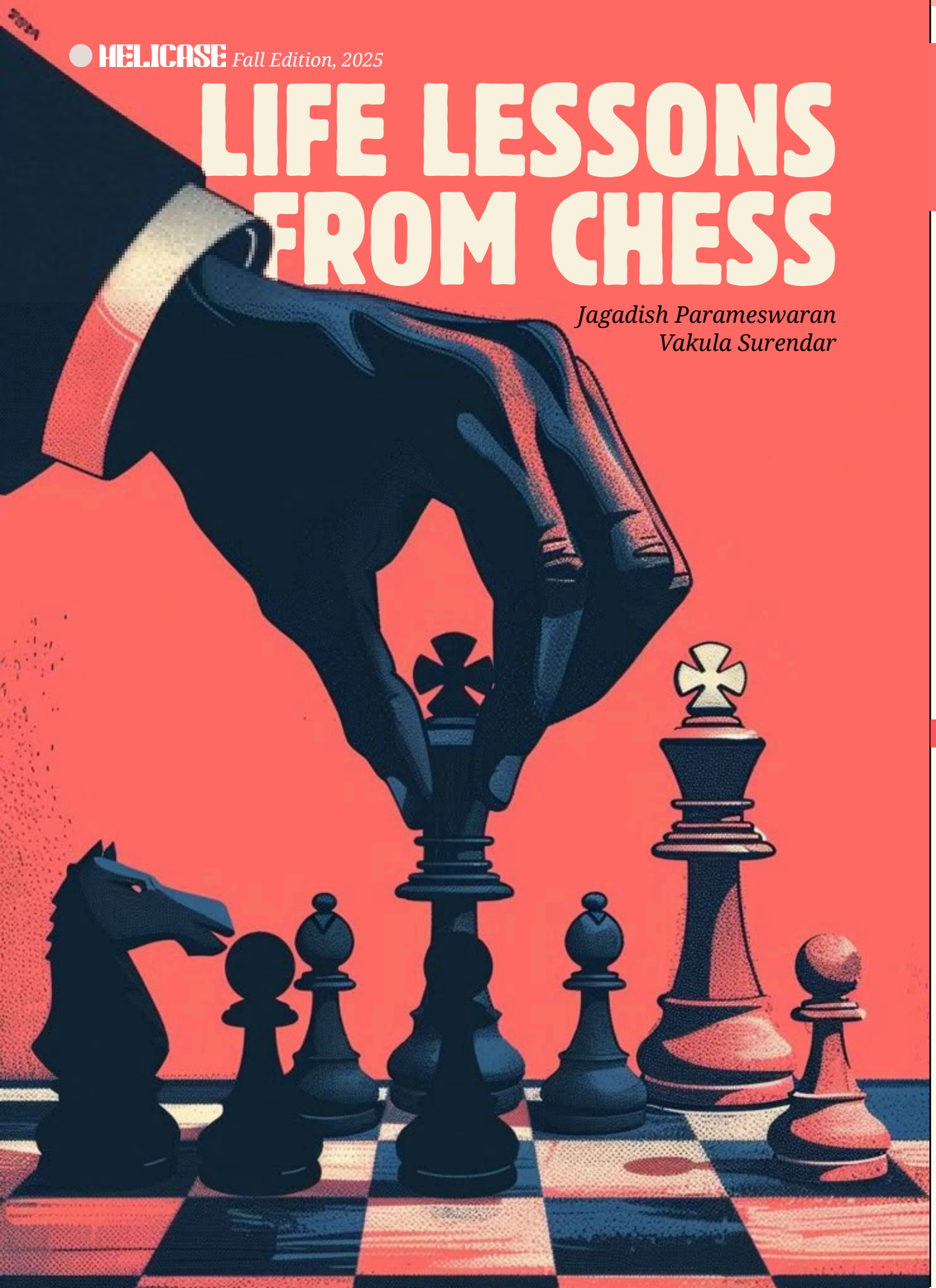
Down

2. A spin that never stops, unless it does.
3. An algorithm walks backwards into a palindrome.
4. The loneliest orbit since Kubrick.
6. Linguistics that loop.

MELICASE *Fall Edition, 2025*

LIFE LESSONS FROM CHESS

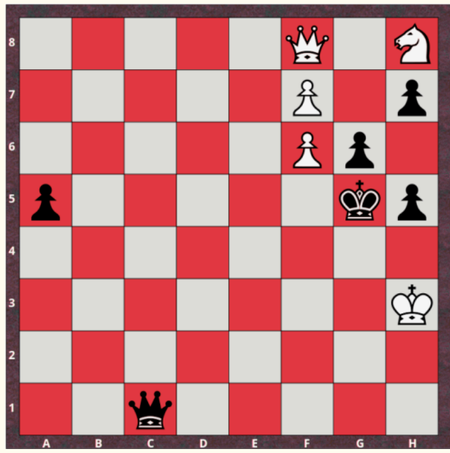
Jagadish Parameswaran
Vakula Surendar



It's not just a pin, after which you win.
It's not just a fork, or a tricked-out quirk.
It's not about tactics, or that wretched mate in six.
It's not calculating deep, or solving it in sleep.
It's about creativity, something new,
An idea fresh, spotted by few,
Not rating, not age, nor experience alike,
A new look at chess is something we all like!

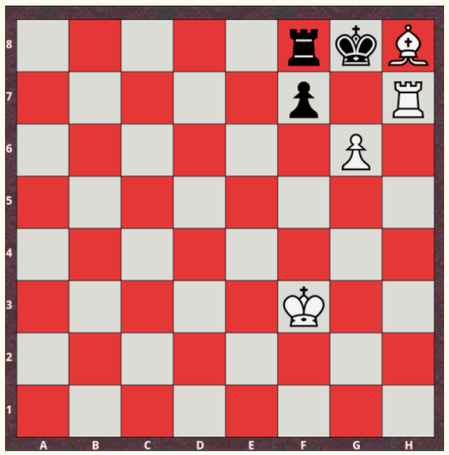
Let's take a break from the intense and harsh chess that is popular in today's day and age, and sit back and enjoy the inherent beauty of the game itself, unveiling some of it's deep and key features, and what general principles we can takeaway from it.

I need space!



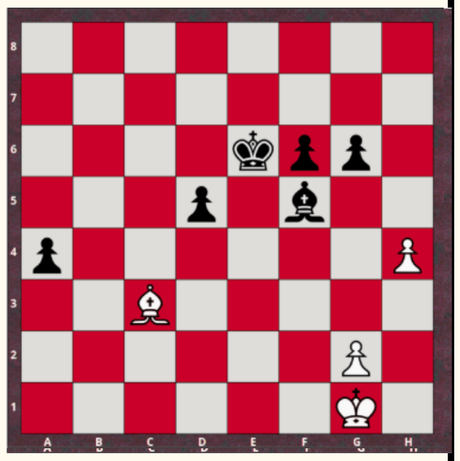
Though White is a knight up for two pawns, along with a passed pawn on f7, things are not so easy. Black's queen can keep giving checks to White, which might result in a draw. So, White must act quick, and creative!
The concept of space is extremely important in chess. The value of a square is sometimes higher than an entire army of pieces. Here's the solution:
1. Qh6+!! Kxh6 2. f8=Q+ Kg5 3. Qh6!!
Sacrificing the second queen on the same sqaure, all this for what? To clear up the important f7 square.
3... Kxh6 4. Nf7#
A beautiful checkmate like the cherry on top! Sometimes, we need to get rid of things in our life in order to make space for more important and exciting things. You may be called stupid, but trust in yourself, (check)mate!

Please get rid of him, dear enemy!



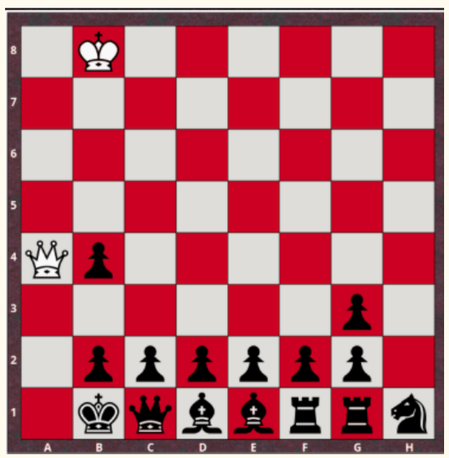
Here's another example of creating space for your self, however, with the help of your opponent (is it called help if you force them into doing it though :)?)
White seems to be winning, with an extra bishop. However, black is threatening fxg6+, which would remove the only defender of White's rook on h7, thereby winning for Black. In order to escape from this threat, White would have to give up the g6 pawn, after which the resulting endgame, though White is a bishop up, is theoretically a draw.
White wins with the stunning
1. Rg7+!!
Giving away the only extra material White has.
2... Kxh8 3. Rh7+ Kg8
Well, now we're back to our original position, without the Bishop on h8. How different is it?
4. g7!
Black is cooked. The f8 rook is attacked, and Rh8+ is being threatened. Either White's pawn promotes, or black loses the rook.
4... Re8 5. Rh8+ Kxg7 6. Rxe8 and white wins.
If I asked you to assess the initial position and the position after move 3, there's a pretty good chance that you would prefer the position with the extra bishop. After all, basic NPC logic is simply: more material → better position. Sometimes, in life, it's wise to not take things at face value, but to always think a step deeper, and critically.

No Time for Caution



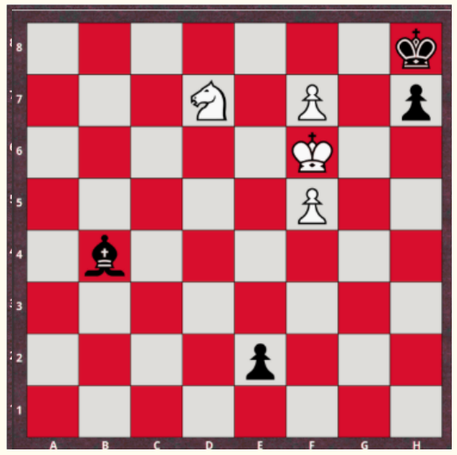
This game is from Vaselin Topalov vs Alexey Shirov, Linares 1988. Let's take a moment to assess this position. Black is 2 pawns up, and has 2 passed pawns. His king is also more active than White's, and well, it might seem like an easy win. But one must never forget the following profound statement: a light squared bishop cannot control dark squares.
It will take white exactly 2 moves to play Kf2-e3, and thus create a bind on the d4 square. Black will not be able to progress. Bringing the black king via the queenside is still tricky because of the loose kingside pawns.
The only way Black can win this game is by getting his king first to e4, before White. But someone's in the way. The bishop! Moving the bishop, and then bringing the King to e4 is too long a process; White's king will reach e3 before that. Shirov found the fantastic
1... Bh3!!
Absolutely wild! One would rate Bh3 as the worst move in the position, it is the only move which instantly loses the bishop. Bh3 spoils White's idea of Kf2-e3, because now the g2 pawn is hanging. Defending that position without the g2 pawn is not possible, so Topalov went ahead with the most natural
2. gxh3 Kf5 3. Kf2 Ke4 4. Bxf6 d4 5. Be7 Kd3 6. Bc5 Kc4 7. Be7 Kb3 and White resigned.
Both the a and d pawns cannot be stopped simultaneously. It's not just about sacrificing those things in life which take away your time, it is to realize that those things could appear to be significantly more valuable than what they are. Giving them up for your bigger goals will be difficult, but is necessary. After all, Black is 2 pawns up not for the sake of being up in material, but to eventually checkmate the White king. The priority is set straight.

Peek a boo!



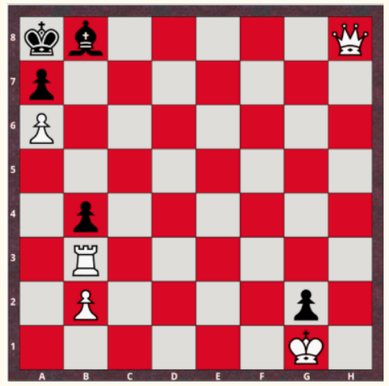
Your opponent has everything, except a knight, and moves! b4-b3 (yes, black is about to promote all those pawns, they are moving downwards) is the only possible move for Black, and White must do something!
White doesn't have enough time, because soon after b4-b3, Black will be left with no moves; a stalemate situation. And if White moves the queen away, then Black can free up by moving the king and promoting the b2 pawn. White has the following ingenious idea
1. Qa8!!
Why there, of all squares, you may ask. Here's the idea. White wants to bring the king nearer to the Black king, eventually to b3. But during this time, White must make sure that black isn't stalemated. The White king intercepts the Queen's control over the a2 and a1 squares, thus giving Black a chance to move. Then White immediately forces Black's king back into the cave. This is how it plays out.
1... b3 2. Ka7 Ka2 3. Kb6+ Kb1 4. Ka5 Ka2 5. Kb4+ Kb1 6. Ka3 Ka1 7. Kxb3+ Kb1 8. Qa2#
Sometimes, we don't need all the things in life to get what we want, whether it's mate or checkmate. A queen and king is all we needed. This puzzle also highlights the famous quote, "Behind every successful King, there is a Queen."

Hope is a dangerous thing...for your opponent!



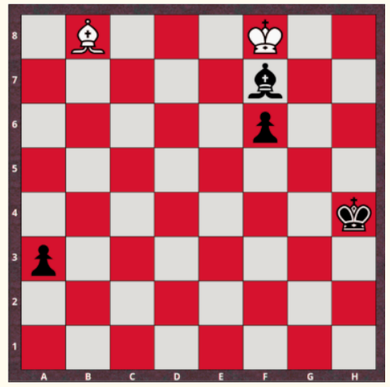
A single glance is enough to observe Black's unstoppable e2 pawn; and White's stopped f7 pawn.
How can White even draw this? Sure, stalemate is what you would want to look for, but you have a knight, for god's sake! How can you force black to get rid of the knight!? Well, the puzzle shows the culmination of two beautiful drawing techniques: the perpetual check, and stalemate, of course!
1. Ne5! e1=Q 2. f8=Q+! Bxf8 3. Nf7+ Kg8 4. Nh6!
The point! Bxh6 leads to stalemate! Kh8 Nf7 is just a repetition. White saves the hopeless position!
Hope could lead to disappointment, but it is also capable of producing such marvels. A popular example which you would relate to is Gukesh. How could a player of Ding's calibre make such a mistake? How could the World's best player, Magnus, lose in such a disappointing fashion, which eventually leads to a table bang? It happens. Fighting till the finish independent of how awful it may be, is a sign of resilience. It is that quality which makes Gukesh so hard to defeat. Hope. Resilience.

You play, I'll watch



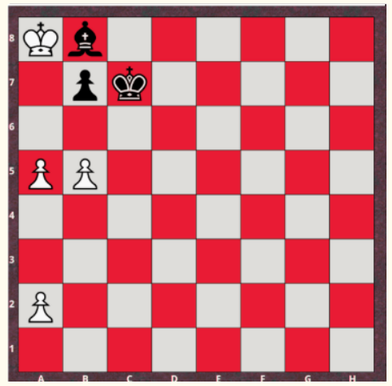
Okay, something easy to calculate. Black has no moves, so we need to give some moves, right? Not too many options too, because we have a constraint, a mate in 3! I will allow the pattern to speak for itself:
1. Rh3!! b3
2. Rh1 gxh1=Q+
3. Qxh1#
How beautiful an idea! The best part about
such compositions is the uniqueness of the solution. You will not be able to find any other mate in 3. Uh, what is the life lesson here, you ask? Well, nothing! Sometimes just have fun in life!

Crafting a Cunning Capture



Another case of hope, another desperate situation. But the important thing in these situations is to remain calm and hone into your creative side
instead of panicking and acting hastily. White goes with the slow:
1. Bd6! a2
2. Be7 a1=Q
3. Bxf6+ Qxf6 stalemate.
Black can literally do nothing about this idea! As slow as it may seem, slithering in with the bishop to f6 is the only way to save this position. Even if Black goes
2... Kg5 3. Bxf6+ does the job.
Sometimes, the speed with which things are done doesn't matter. If the plan is strong enough, it speaks for itself. No matter how slow it might seem, if it's strong, it will work.

Your turn. No, your turn!



We end on a classic, chess buzzword themed puzzle. Yes, zugzwang! White's king is stuck on a8, but the pawns will fight and make the king proud! They will take charge and make moves, or rather, not make moves, forcing the opponent into a zugzwang, which means, a compulsion to move. White first starts with creating a passed pawn.
1. b6+ Kc8 2. a6 bxa6
3. b7+ Kc7 4. a3!!
Brilliant! White must force Black's king or bishop to make a move, which would result in Black losing the Bishop. Hence, a3 (instead of a4), loses a move, thus forcing black to play.
4... a5 5. a4 and White wins.
The life lesson from this is obvious. Eat 5 Star, and do nothing... sometimes!

APPENDIX.

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