Anveshanā

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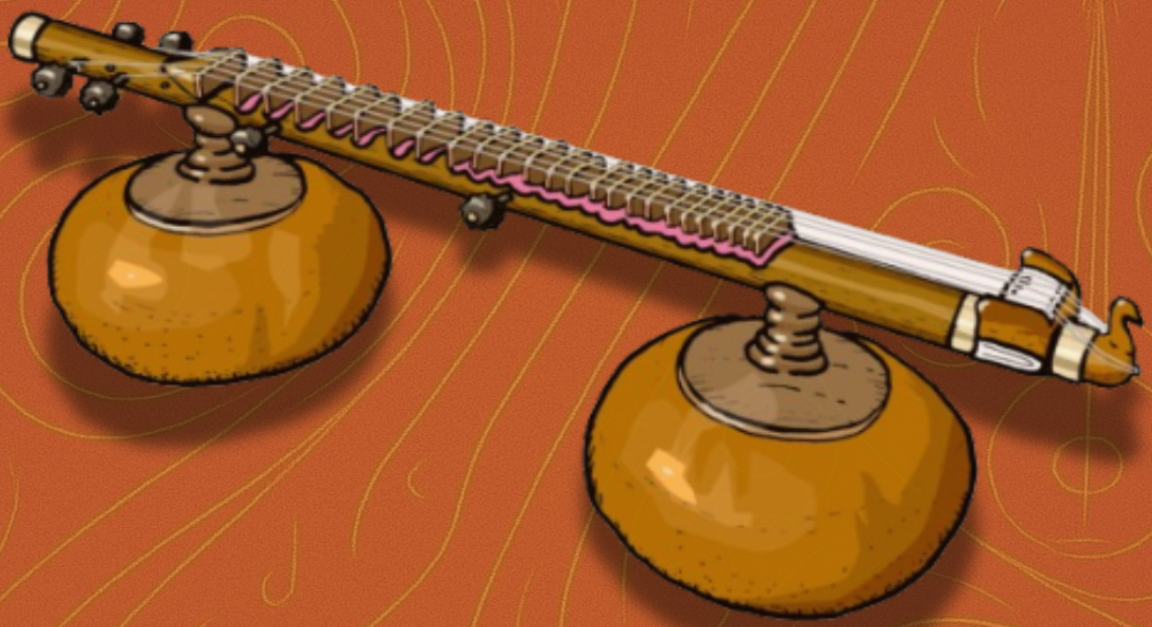

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A GOODBYE BY UTKARSH KASHYAP

Dedicated to those who dream boldly, venture endlessly, and share generously

In the Echoes of their Light
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Dear Reader,

A season and more have blossomed, and we arrive anew—with a new light to offer. A fresh variation of the truth, a different glimmer of understanding. Just as light reveals and its absence deepens reflection, this edition brings you yet another perspective in our ongoing quest—the *Anveshanā*—of truth, of knowledge, and of our own being.

What you now behold, is a new blend of insight, imagination, and curiosity—a fresh lens through which to see the same eternal questions. Another permutation of truth, another reflection of the infinite and another feather to the hat of imagination.

We extend our heartfelt gratitude to the friends of *Anveshanā*. This initiative has been nurtured by the faith of many, and its unfolding would not have been possible without their support. We continue to draw strength from their presence, and look forward to walking further together.

In this issue, we delve into the divine found in the miniscule—the wonder within proteins, the punctuational discipline in and the rich cultural relevance in the origin of the name, the forlorn and un-delivered goodbye in the hopeful awakening of an arrival and the soul of sound living in the raagas, while theorising and reflecting on a life of teaching. Here, the miniature holds the magnificent; the minute becomes the mystical.
This issue brings to you- another Resources Palette- a rich collection of resources which hold the power to illuminate the minds and paint the canvas in colors of courage and might.

We invite you once again to journey with us—into thought, into feeling, and into the quiet revelations that lie between the lines. And we, again, leave you to the pages and the journey which lies ahead- a beautiful revelation of life and the living.

With warm regards,
Co-editors,
Devang Bajpai
Purnima Tiwari
Aayush Verma

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Interview

A life Lived and Taught: Interview with Aparna Dar

Prof. Aparna Dar Aparna Dar

Aparna Dar is a mathematician and an emeritus professor at the Indian Institute of Technology, Kanpur, with research interests in Topology and Knot Theory. She completed her Ph.D. at the State University of New York at Stony Brook under the guidance of Jeff Cheeger, focusing on aspects of Knot Theory. Since 1989, she has been teaching mathematics at IIT Kanpur.

In this interview, Prof. Dar reflects on her mathematical influences, her doctoral years in US, her views on the ethical responsibilities of the individual, her time at IITK and her longstanding engagement with teaching.

How would you describe your childhood? What were your early interests? And did you always have an inclination towards mathematics?

Aparna Dar: I was born and brought up in Kolkata, even though my parents were both of Kashmiri Pandit origin. My father, *Shri Swaroop Krishna Dar*—an engineer in the Indian Railways—always had distinction in mathematics as a student, and my mother, *Smt. Kiran Dar*, was a gold medal student of economics. However, as I lost my father at the very young age of 12 years, I was brought up by my maternal family in Kolkata.

Yes, mathematics always attracted me very strongly since my childhood, and I was always winning prizes for mathematics in my school days. And since my maternal family was very spiritually inclined, my other childhood interest was reading the works of great spiritual masters like Swami Vivekananda, who has deeply influenced my thinking and personality.

How would you describe your undergraduate years? What led you to join IIT Kanpur for your master's studies? Which courses and individuals had a significant influence on you there?

AD: After completing my schooling, I wanted to continue with higher studies in mathematics, and some family friends suggested that IIT Kanpur was a very good institute to learn mathematics. So I prepared for JEE and got selected in the Mathematics Department of IIT Kanpur in 1975. We had excellent professors in the department, who not only excelled in their work but were also very generous and kind to me as a young student. Among them was *Prof. Krishna Tiwari*, who worked in Algebra, and *Prof. U. B. Tiwari*, who worked in Analysis, amongst many others. Somehow, I got interested to work in Topology and Geometry, and my kind teachers wrote my recommendation letters to go to SUNY Stony Brook, where I started my PhD in mathematics.

"My main purpose was to impart the kind of education that Swami Vivekananda's writings talk about, i.e., "Education is to teach students self-confidence in their own abilities, and to learn to think for themselves."

How would you describe your time at IIT Kanpur so far, both inside and outside the campus? What changes have you witnessed since your master's studies?

AD: There have been many changes at IIT Kanpur since my student days and up to the present, during which I have been working here as a faculty member.

In our student days, the human touch between students and teachers was very strong. We would visit their homes, and they treated us like family members. This was an invaluable gift, as we absorbed a lot of wisdom and maturity from our professors.

When I joined IIT Kanpur in 1989, my main purpose was to impart the kind of education that Swami Vivekananda's writings talk about, i.e., *"Education is to teach students self-confidence in their own abilities, and to learn to think for themselves".* At the time, many wonderful young students joined me for their master's projects—such as *Harish Seshadri* and *Punita*

45th alumni reunion of Class of 1980 in March 2025. Aparna Dar

Batra—who have today become excellent mathematicians. It was a joy for me to have the opportunity to help these students in their formative years.

Also, I learned a new field of mathematics, a branch of Topology called Knot Theory, and solved an open problem on Kirby's List of Open Problems in Low-Dimensional Topology in 2005. Thereafter, many students wanted to do projects on Knot Theory with me, and they even enjoyed learning it a lot in my courses!

Presently, student numbers have vastly increased, and due to extensive online resources, the human connectivity with faculty has diminished. This is unfortunate, because it is through personal contact alongside the care and wisdom of senior faculty that young students learn the valuable lessons of human life.

How would you describe your time at SUNY Stony Brook? Which areas of mathematics drew your interest during that period?

AD: I was accepted into the Ph.D. program in Mathematics at SUNY Stony Brook in 1980. In those days, Stony Brook was a truly wonderful place to be—both because of the exciting work in Geometry and Topology in the department at the time, and also because of the friendly, cosmopolitan atmosphere of the University.
We formed a close circle of friends at SUNY Stony Brook, and some of us have remained lifelong friends.

What was it like working with Professor Jeff Cheeger during your doctoral studies?

AD: It was very fortunate for me to be accepted by *Professor Jeff Cheeger* as a doctoral student. At the time, he had several Ph.D. students (maybe 4–5), and he kindly accepted me among them. Professor Cheeger is a mathematical genius, but alongside, he is also a very generous and good-hearted professor—a very rare combination, and I feel privileged to have been his doctoral student.

Jeff Cheeger. ©NYU

What was the focus of your doctoral thesis at SUNY Stony Brook?

AD: In the early eighties, Prof Cheeger had solved a famous open problem on the equality of the analytic torsion, and a topological invariant— the Reidemeister Torsion. This path-breaking work was published in the *Annals of Mathematics*. From this, Prof Cheeger began the study of analysis on spaces with singularities, i.e., pseudomanifolds, and was very actively doing path-breaking research in this area. This was the time he accepted me as his doctoral student, so he suggested a problem of extending analytic torsion and the topological Reidemeister Torsion to pseudomanifolds. Though it was challenging, based on the Intersection Homology Theory of *Goresky* and *MacPherson*, it became possible to generalise the analytic torsion to pseudomanifolds, and also define a topological invariant, the Intersection $\mathcal{R}$-Torsion, and to prove equality in some special cases. This work, done over 2-3 years, became my PhD thesis at SUNY Stony Brook.

Do you have interests outside of mathematics—such as philosophy or music? Have these other dimensions helped inspire your work, and if so, in what way?

AD: Apart from mathematics, I am also deeply interested in the spiritual traditions of the East and West. Having read Swami Vivekananda extensively in my childhood and during my student days, I felt the beauty of our ancient Upanishadic culture, which accepts all paths to the Divine as true.

Quoting from the Sanskrit: *"Ekam sad viprā bahudhā vadanti"*—Truth is One, but it manifests in infinitely many names and forms. Thus, every spiritual tradition leads to the realisation of the Transcendental Divine Light. Another beautiful concept in our ancient Vedanta is: *"Vasudhaiva kutumbakam"*—the whole world is one family. Lastly, quoting from Swami Vivekananda is the idea that: *"Service to others is the highest form of worship"*—*"Nara is Nārāyaṇa"*, and similarly, *"Jīva is Śiva"*.

Personally, I am initiated into the ancient Gayatri Mantra, (a prayer for wisdom) from Shantikunj, Haridwar, since the last 25 years or so.

You solved Kirby's open problem in knot theory—namely, whether there exist alternating amphicheiral knots of every even crossing number—with a positive, constructive class of examples. How was the process for you? Did you approach the problem intending to solve it, or did the solution arise more as a realisation along the way?

AD: It all started when I began reading a paper by *Prof. Vaughan Jones* (who discovered the Jones polynomial). The paper is titled *"Hecke Algebra Representations of Braid Groups and Link Polynomials"* and was published in the *Annals of Mathematics*, 1987. In this paper, in the appendix on page 381, Prof. Jones gave a table of all the knots up to crossing number 10, their braid representations, and their polynomials.

It was this table, in the appendix, with which I just began calculating Jones polynomials in terms of their braid representations. In fact, my approach was quite experimental— in that I calculated Jones polynomials of many closed braids, and then tried to see if there was any connection between them.

To my great surprise, I did find a connection, and then I just stumbled upon the solution to the Kirby problem. In this process, I discovered many symmetries and formulas for the Jones polynomials that were quite amazing. Probably many discoveries are made in this manner!

Aparna Dar with her students during a topology course. Aparna Dar

Do your undergraduate students take interest in your work on knot theory?

AD: Actually, undergraduates here at IIT Kanpur have been enjoying knot theory, which I have been teaching to them since 2005. It is full of open problems, and sometimes undergraduates even come up with original insights!

Are there any open problems in knot theory that continue to fascinate you?

AD: Yes, there are many open questions

still unknown about the Jones polynomial. For example: is there a nontrivial knot whose Jones polynomial equals 1? Not just me, but a large number of mathematicians have been intrigued by questions like this!

Did your interests in differential geometry ever prompt you to explore theoretical physics or consider working within it?

AD: Though I have had many physics students, my own knowledge of physics is very limited, so I have remained within the domain of mathematics only.

How was your experience at the other institutes where you spent time during your postdoctoral years—for instance, IAS, TIFR, ICTP, and others?

AD: IAS, TIFR, and other such institutions are among the most eminent centres for research in mathematics, and it was a privilege for me to spend time in such citadels of higher learning.

You are also a long-standing member of *Manushi*. What is its focus?

AD: Yes, I have been a member of *Manushi* for more than 25 years, as it engages with the real-life challenges faced by women in Indian society.

What do you think about the ascetic nature of mathematics? Do you think such a thing exists? How does a career in mathematics—or academics more generally—impact the daily life of a family person?

AD: As I understand it, mathematics began as a language for understanding and describing nature. Thus, in the classical period, mathematics and physics were very closely interrelated. For example, Newton invented calculus as a language and tool to describe his laws of motion, and Einstein used Riemannian geometry to describe his general theory of relativity.

Aparna Dar with her students on the occasion of *Basant Panchami*, 2025. Aparna Dar

Mathematics, being abstract, does possess an ascetic nature. But it also seems to be an innate, inborn talent in some people—something like music. However, many mathematicians, including legendary figures like Euler and Gauss, have led very normal, happy lives, much like other creative individuals.

Do you feel that the works of ancient and pre-colonial Indian mathematicians—such as Āryabhaṭa, Bhāskara, Brahmagupta, and Mādhava—are underrated and insufficiently

Aparna Dar with her students. APARNA DAR

valued in the current state of education in our own country?

AD: Yes. If more people understood Sanskrit, they could translate their works, and I am sure that much advanced mathematics might have been known to Indian mathematicians, but has not yet been discovered.

I do feel that in the ancient and pre-colonial era, Indian mathematicians knew a great deal of mathematics that we are no longer aware of. For example, they had precise knowledge of astronomy, planetary movements, and the exact timings of solar and lunar eclipses. How could they have known all of this without a deep understanding of mathematics?

Thus, I would conjecture that a significant amount of mathematical knowledge existed in that period, but has been lost over time.

Do you think that the lack of Sanskrit literacy today has limited our ability to recover some of these ancient contributions?

AD: Yes, we need people with good knowledge of Sanskrit to search through the Indian mathematics of earlier periods.

Let's talk about education in mathematics in this country. What is your view on the current state of mathematics education in India, especially at the school and college level? Do you feel we are on the right path in cultivating mathematical talent?

AD: Mathematics education in India seems to be doing very well. We have so many young, brilliant mathematicians working in India, and so many institutes like the IISERs and the

new IITs. So, I think India is doing very well presently.

How do you approach the challenge of making abstract mathematical concepts accessible to students?

AD: I think we need to provide concrete examples first, and then build up the abstraction through them. This is a principle I have consistently followed in my teaching, and it works well.

What makes a teacher special and different from a researcher—specifically in mathematics?

AD: The teacher who can bring out the best in their student is the one I would consider 'special.' For example, Gauss was the teacher of Riemann, and surely he must have been a wonderful and truly special teacher to have nurtured a brilliant genius like Riemann.

A teacher must derive joy from empowering and serving young students. When this spirit is present, all techniques and methods will follow naturally.

What do you expect from an honest student in your course? What qualities, in your view, help a student go far in mathematics?

AD: I have had many meritorious students who have done really very well. Basically, honesty and integrity of character, and respect for learning and for teachers, take students very far!

What is an academic's duty—particularly as a mathematician—to society? How can one contribute beyond the scope of their research work?

AD: An academician's duty is to pursue their work in a way that benefits society as much as possible.

"The teacher who can bring out the best in their student is the one I would consider special."

Since an academician is a person of learning and wisdom, I believe that, along with teaching the technical and intellectual aspects of their subject, they must also embody integrity of character and conduct in every way. They should stand tall, like a lighthouse—serving as a guide to society in times of difficulty and crisis, such as our modern times.

If *Anveshanā* wanted to inspire young people to pursue abstract thought or explore various forms of mathematics (and of course, beyond), what would you suggest as a starting point?

AD: *Anveshanā* could carry engaging articles on different areas of learning, as well as inspiring examples of creative individuals.

As you are already doing, I feel that *Anveshanā* can interview a wide cross-section of academicians in order to present diverse perspectives from various kinds of thinkers. You may also invite some of the young and brilliant faculty members to write expository articles on their areas of specialisation, so as to make these subjects accessible to students.

Overall, I feel *Anveshanā* can become a source of great inspiration and intellectual interest to many—especially young learners. I extend my heartfelt good wishes to the editors!

This interview was conducted over email correspondence.

Interview

Of Mind and Matter: Interview with Sumathi Rao

Sumathi Rao giving a talk at HRI around (c. 2009–2010). Sumathi Rao

Sumathi Rao is a theoretical physicist presently based at the International Centre for Theoretical Sciences (ICTS-TIFR), Bengaluru. Her research lies primarily in the domain of condensed matter physics. Prior to this, she was a long-standing faculty member at the Harish-Chandra Research Institute (HRI), Prayagraj (formerly Allahabad), where she served for fifteen years. Prof. Rao received her doctoral degree in particle physics from the State University of New York at Stony Brook.

In this interview, Prof. Rao reflects on her early years in Vadodara, her formative experiences at IIT Bombay, her time at SUNY and the friendships, her engagement with art and music, and her journey through the world of science.

Purnima Tiwari: How would you describe your childhood? Did you always have an inclination towards Science?

Sumathi Rao (top row, second from the left) with her school friends in 1973 (Class XI). Sumathi Rao

Sumathi Rao: When I was a child, I was always interested in logic and puzzles. I used to read a great many detective stories and was fascinated by the process of finding things out. During the final years of high school, I happened to come across one of the volumes of the *Feynman Lectures on Physics*. Although I did not understand many of the concepts at the time, I found the book to be extremely well written and was deeply interested in reading it. That was how I gradually became interested in physics during high school. The language of the lectures was also quite compelling. Since I was interested in English literature at the time, Feynman's lectures struck me as a work that was not only elegantly written but also rich in scientific content, which greatly appealed to me.

PT: As you have mentioned that you liked reading detective stories, did you ever think, as a child, that you would be a physicist in the future?

SR: No, when I was younger, I wanted to be a detective—like many kids, I suppose, at that time. Alternatively, I wanted to be a writer, but that was also when I was very young.

PT: What were the early influences on you? You mention that you were mostly interested in detective stories. But apart from that, were there any forms of music, arts, or sports that you explored on your own or with others during your childhood?

SR: I come from a South Indian family, and we were all taught Carnatic music as children—it was an integral part of our cultural upbringing. That was primarily during my early childhood. Later on, of course, we all used to listen to Hindi music.

I was fortunate to grow up on a campus, and we used to play badminton every evening. I participated in tournaments and even won medals—during that time and throughout my years at IIT as well. In Gujarat, where I lived back then, there were not many women in sports, so

we had greater opportunities, especially because we lived in the IPCL (Indian Petrochemicals Corporation Limited) colony. That gave us access to many facilities, and we even went to Anand (of Amul fame) to witness state-level and national-level badminton matches. Some of us also participated in state-level competitions at that time. In addition to badminton, table tennis was quite popular in our colony, and we used to play that regularly. These activities were mostly outside of school—organized within the colony. The colonies were small and inclusive, so both boys and girls played together. That was beneficial for us, I believe, because growing up with such mixed participation improved our games and our confidence.

Aayush Verma: So you belong to a South Indian family? Then who in your family moved to Gujarat?

"I cannot go to sleep unless I read a novel at night. A novel, meaning something that is not science."

SR: My dad was working at IPCL, so that is why I lived in Gujarat. I was born in Hyderabad, and for six years, my dad was in London. So we were also there, and then later on, we came back to Hyderabad. When I was about twelve, we moved to Vadodara. So my early childhood was in Hyderabad, and then later in Vadodara. And my dad was always interested in puzzles and logic, so he would give us books like those by *Martin Gardner*. That is another book I remember that we read. Mathematical puzzles, logical puzzles—those were all fun things to do.

PT: You seem to have a keen interest in English novels. Can you possibly list a few which are your favorites genres? And have you continued your reading journey in terms of novels thus far?

SR: Well, right now, the only thing I continue to do—which has been, and I think will continue to be, with me all through my life, even when I have been extremely and completely involved in science—is reading. I cannot go to sleep unless I read a novel at night. A novel, meaning something that is not science.

Fictional reading has always remained; it has always existed in my life. Over the years, my tastes have changed. Now I read a lot of Indian writers as well, which I never used to read earlier. Even now, on campus, in our colony, I belong to a book club. Everyone picks books to read, and once a month or so, we meet to discuss them.

PT: Can you list a few of your favorites?

SR: My early favorites used to be authors like *Jane Austen* and others similar to her. That was when I was in college and for many years afterward, because I still think she is one of the excellent writers. And then, all the old classics—like *[Charles] Dickens* amongst others.

But now, what I read is not all those things. I continue to read a lot of detective stories, which are probably a staple. I read science fiction too. *The Three-Body Problem* is a recent, fantastic

novel in that genre. In detective novels, there is one that combines detective fiction and science fiction—*The* $7\frac{1}{2}$ *Deaths of Evelyn Hardcastle*. Have any of you read it?

PT: I am mostly into classics and contemporary fiction and nonfiction.

SR: In the recent Indian authors in contemporary fiction, I like *Amitav Ghosh*. And *Rian Malan* is another one of the writers I like. He is from South Africa, and pens some unusual literary accounts. I'm right now living in Bangalore, so I probably should read *Bano Mushtaq*, which I have not read yet. *Salman Rushdie* is another great favorite of mine, and I have read most of his books. So those are the kinds of books that I like.

AV: What are you reading currently?

SR: Right now, I am just thinking about what the most recent book is—the one I've been reading with the book club in our housing colony. It was —again, a science fiction novel: *Recursion* by *Blake Crouch*.

And if you're really asking me what the latest book I've read is—well, it's something I came across recently. I had gone to my sister's house, and we were all looking through our old books, which included one that I had received as a prize. It happened to be by *Alistair MacLean*, from my school days. I don't know if any of you have read Alistair MacLean—it's probably way too old now. Some of those books were later made into movies: *The Guns of Navarone, Fear Is the Key*—these were all adventure books from the time when I was in school. I like re-reading old books.

Devang Bajpai: You chose physics over engineering, right? Do you think that, back then, it was a good decision, or would you want to reverse it?

SR: Yes, actually. I chose physics over engineering, and it was not a particularly difficult decision for me, because my parents were quite okay with it. I think in those days—this was about forty or fifty years ago—my parents were comfortable with me studying anything. They were not overly concerned about how I would earn my living, and so on.

In those days, I think that if it had been a boy who wanted to study physics rather than engineering, there would have been more pressure to change the course. My brother, who is almost ten years younger than I am, took engineering. My younger sister, who is two years younger, also took engineering.

My father wanted one of us to pursue medicine, but we were all very squeamish and did not like medicine at all. So we all ended up in science and engineering. So yes, it was a very good decision in retrospect. Engineering was also interesting at that time. My sister went into computer science, and that was a different kind of life. But I think, in retrospect, it was the right decision for me.

AV: Did you write the JEE exam?

SR: I did not write the JEE exam. However, I was offered direct admission to a five-year IIT programme, because at that time, I was an NSTS (National Science Talent Scholar) and also a rank holder in my board exams.

AV: And you did not choose to go there?

SR: No, I did not choose to go there. At that time, I was very homesick. I had originally planned to go to IIT Bombay, but later I changed my mind and decided to pursue a B.Sc. at MS University in Baroda (currently Vadodara).

DB: Did you have any physics heroes when you were young?

SR: I would say *Feynman*, probably—simply because his Lectures on Physics was the physics textbook that I loved. I think I first came across Volume 3, which is Quantum Mechanics.

AV: Was this in high school when you picked up Feynman? Did the teachers recommend you?

SR: Class 11 or 12, , I think—that is when I was reading Feynman. It was not part of my school curriculum. And once I got the National Science Talent Fellowship, from then on, every year I used to buy some books—some *Scientific American* old volumes, collected issues, etc. At that time, more than textbooks, it was popular science that attracted me. While pursuing my B.Sc., I had a very good physics teacher named *Prof. J. S. Bandukwala* at the Maharaja Sayajirao University of Baroda, which was a small university. Undergraduates were taught by the university professors themselves. There were no associated colleges, because Baroda is a very small town. So the university professors directly used to teach us, and if some student was interested, they themselves used to take a lot of interest.

"I would say Feynman, probably—simply because his Lectures on Physics was the physics textbook that I loved."

There were a couple of people—one was *Prof. Madhuben Shah* from Berkeley, and I forget where Prof. Bandukwala did his Ph.D., but he was a very inspiring teacher. His office was always full of students, he would still tell us stories about the Los Alamos atom bomb project, Oppenheimer, etc., among other things we would not otherwise come to know of. I think those things were very nice and motivating.

Then, for my M.Sc., I went to IIT Bombay, where our class had a large number of girls. So we had a very nice batch where we could discuss things. And once you go to IIT, I think things become streamlined. Everybody would apply to go abroad for a Ph.D., and you would do what your seniors did. But the decision to go to Bombay—and this was more than forty years ago—for all of us, not just for me, required parental approval. All the other girls who came also had to be allowed by their parents to be away from home and pursue their careers. This was, comparatively, much less common than it is now. It is probably still uncommon.

AV: I also wanted to ask you: which part of physics excited you the most in those days, especially when you were finishing your Bachelor's and moving into your Master's? And why did you choose IIT Bombay?

SR: In Baroda, I read a lot of popular science, and many of those things had to do with particle accelerators and so on. So yes, pursuing particle physics was my aim when I went for my master's.
And IIT Bombay was a choice because it was the closest to home—as simple as that. I remember that there was a clash in dates for the IIT Bombay and the IIT Kanpur exams, and I chose IIT Bombay.

AV: Were you clear about doing particle physics during your Bachelor's?

SR: Yes, I would say that. Although, I did not have a lot of knowledge, I had the feeling that I wanted to pursue theory rather than experiment. So, if someone asked me, I would always say particle physics. It sounded like the most exciting area to me—finding out what things are made of.

Some people were more excited about astronomy, but I was always inclined toward asking: what is it made of? Going deeper and deeper, breaking things down, and trying to understand their fundamental constituents—that always appealed to me.

AV: Do you think that happened because particle physics was mainly in the news at that time? Because every day something was coming up in these accelerators that the general audience was also interested in?

SR: Yes, I think so. I didn't even know if something was happening every day, but a lot of the popular science articles made it sound that way. But of course, everyone follows fashion. I think it had more to do with that than anything else—not that we really understood it deeply. And that is true even of the students who come today. Many of those who want to study string theory don't really know about it—they just know that it's very exciting.

"It sounded like the most exciting area to me—finding out what things are made of."

Yes, so with particle physics—it sounds exciting, right? That you get to know what things are made of at the deepest level.

AV: And what was your master's thesis then at IIT Bombay? What did you work on?

SR: I worked on something called 'neutrino–antineutrino oscillations'. It falls within particle physics. This area involves extremely light particles that do not interact electromagnetically; they interact only via the weak force. At the time I was working on it, it was believed that neutrinos were massless. It was much later—sometime around 2000—that it was discovered they do, in fact, have a very tiny mass. So, neutrino oscillations were a major topic of interest

back then, and that is what I worked on for my master's.

AV: So after that, you decided to move to Stony Brook in the USA. How did you choose to go there? Did something in particular attract you to that place?

SR: Yes, one of my seniors, *Neelima Gupte*, who was a year ahead of me, had gone there. And basically, the way it worked in those days was that you applied to places that did not ask for application fees. First, you would send what were called "pre-apps" to about twenty places, and then you would send full applications to four or five universities.

You chose universities based on the advice from your seniors and professors, and you would get to know about the places where you might have a good chance and which did not ask for an application fee. So, Stony Brook did not have application fees, and hence a lot of Indians went there at that time. Sometimes, you would apply to one high-profile university like Princeton, just for the possibility. I have forgotten where I had applied for a high-level place, though. I think I had gotten into Stony Brook and one more place, which was maybe the University of Illinois Urbana-Champaign.

There were not many choices, and there were several of us who were applying from my class. So we would also try to divide up the places so that not everybody applied to the same place. Also, since our teachers had to write many recommendation letters, each of us would typically apply to about three or four places, to avoid overburdening them. That was how it was done back then.

AV: What was the Department of Physics at Stony Brook like during your time there?

SR: Stony Brook had a very strong Department of Physics back then. There were many faculty members, and the particle physics group was particularly active. By that time, I had already decided that I wanted to do my Ph.D. in particle physics.

C. N. Yang was there, working on parity violation, and he was the head of the Institute for Theoretical Physics. I remember, in our very first semester, all of us went to sit in on his course on gauge theories. We were not registered for it, and we did not understand much, but everyone just wanted to see him and listen to him speak. A lot of the names that you would read in books and papers—when you see them, you'd get very excited—so that was what happened. Also, at that time, Stony Brook had a very good Indian representation. There were five Indian students in the senior batch, five in mine, and another five or so in the next batch. Altogether, the department had about twenty Indian Ph.D. students, which created a strong and supportive community.

AV: Among the students from Stony Brook, how many eventually returned to India?

SR: A large fraction of the Stony Brook students did come back. Compared to most of the other universities, I think quite a few of us returned to India.

AV: Could you share your personal experience of your time at Stony Brook?

SR: I think the time you influence each other the most is during the IIT years or the Ph.D. years. In my case, it turned out to be the Ph.D. years which created an enormous difference in my life. I think all of us influenced each other a lot. All of us used to like reading books. We used to talk about other things besides physics—like politics, etc. Sometimes it happens a little earlier for some people. That is, for some, the most formative years are the IIT years. But for me, I would think my Stony Brook years were very formative. That's where I met, of course, my husband, *Ashoke Sen*, also. We learned a lot of physics from one another—apart from what the faculty taught us formally. There was a great deal of informal learning. Because we would have lectures and classes, then we'd go out for dinner, then all of us would go back to our offices in the Institute—and work, play, discuss, everything together, as we lived in the dorms then.

Sumathi Rao (in the center) with Ashoke Sen (top-left) and friends from SUNY. Sumathi Rao

AV: Was Prof. Sunil Mukhi at Stony Brook at the time as well? And were Prof. Rohini Godbole and Prof. Aparna Dar there too?

SR: Yes, Sunil Mukhi was there. Rohini Godbole had already left before I joined. Aparna Dar was there, but she was in the Mathematics Department. Neelima Gupte, Ghanashyam Date, and Ranjan Ghosh were also there.

Many of them came back to India—Date came back, Ranjan came back, Neelima came back. Sunil, Ashoke, and I came back too. Very few people stayed abroad.

AV: Many physicists and mathematicians have historically gone abroad after their master's degrees. Why do you think this was the case? Why did people choose to pursue their Ph.D. overseas? Do you think the situation is any different now? Are more people staying back in India for their post-graduation studies?

SR: I think more people stay back now, because there are many more places in India. It didn't even occur to us to do a Ph.D. in India. Places like TIFR were considered elitist, so we didn't really think about them. And there was not much discussion about TIFR or IISc in those days.

I had a very good friend in IIT who wanted to stay back in India, *Chayanika Shah*—she did her Ph.D. at IIT Bombay, and she is now a well-known feminist and LGBTQ activist. And then there was somebody else from my class named *Prajval Shastri*, who did her Ph.D. at the JAP programme in Bangalore, in astrophysics.

"Science, of course, is universal—it is an international subject. There is no such thing as national physics or anything like that."

But unless people had some reason to stay back in India, the general idea was to go abroad. There was a one-time investment—the amount of money you had to put in for the ticket—which was large, and getting a visa and a ticket to the U.S. was not easy for most middle-class families at that time. But you could somehow manage it. Then afterwards, everything was on scholarship. The scholarship money you received was sufficient to live there reasonably comfortably, and we could come back to visit India occasionally.

Whereas in India, the Ph.D. stipends—although they existed—would not have been sufficient, perhaps. But we never really thought about it. The idea back then was that science was something which was done abroad. I think that has changed now, because there's a lot more science being done in India.

And the institutes that were prominent in those days, like the IITs, were not known for research—they were simply supposed to be good teaching institutes. So it didn't occur to us that one should stay back for a Ph.D. I certainly think things have changed now, but still, there are a large number of visiting students here at ICTS as well, who come here to pursue their master's thesis, and a large fraction of them do want to go abroad.

And to be honest, I think there are advantages to doing that. Firstly, science, of course, is universal—it is an international subject. There is no such thing as national physics or anything like that. And you do learn a lot by seeing the world and meeting very different kinds of people. Many people go abroad simply to 'grow up'. One way of saying it is that by leaving home and going abroad, they learn to fend for themselves.

Sumathi Rao with Robert Shrock, his wife I-Hsiu Lee and their child in late 90s when Rao was visiting SUNY. Sumathi Rao

DB: How did you come in contact with Robert Shrock, and what work led you to choose him as your Ph.D. advisor?

SR: *Robert Schrock* taught us a course in Particle Physics. He was young at the time and had just started teaching. These things happen somewhat organically—you try to choose appropriately from the available options. I mean, there was another new faculty who had come in that semester called *George Sterman* whom

Ashoke and some other students approached. But I was keen on working in particle physics, and I wanted someone whom I could approach easily and who might take me on as a student.

I had done reasonably well in his course, so I thought it was worth trying. Also, at that time, he was working on neutrino oscillations, and since I had worked on neutrino oscillations for my master's thesis, I thought I might have some background on the topic. But actually, I ended up not doing my project in neutrino oscillations, but rather in something called 'neutron-antineutron' oscillations. This was a topic related to the Grand Unified Theory (GUT). Around the early 1980s, there was considerable excitement around unifying the fundamental interactions. The weak and electromagnetic forces had already been unified in the 'Weinberg–Salam' model[1], and people were exploring whether the strong interaction could also be incorporated into a single framework. And in this grand unified theory, protons were supposed to decay. In India also, people looked for the proton decay in the Kolar Gold Fields. There's a very famous experiment in the Kolar gold field where they claimed that the proton did decay. And it turned out to be wrong. Nevertheless, it triggered a wave of interest and several conferences were held on GUTs and baryon number violation.

Now, in the case of neutron–antineutron oscillations, the process involves a violation of baryon number (B) by two units, instead of the single unit in proton decay. Since the neutron is a neutral particle, such an oscillation is theoretically allowed. In terms of the quark model[2], a neutron consists of udd, and an antineutron would be $\bar{u}\bar{u}\bar{d}$. So, one could, in principle, have a transition of a neutron into an antineutron, analogous in structure to neutrino oscillations. And you could think of a neutron oscillating into an antineutron in the same way that you would think of neutrino oscillations.

However, this process would require $B - L$ (baryon number minus lepton number) violation, not just baryon number violation. That was my Ph.D. thesis. We calculated how such oscillations could occur, what the possible mechanisms were, what the decay channels would look like, and what experimental signatures one might expect and how would they oscillate? Those kind of things.

Neither proton decay nor neutron oscillations have been observed so far. But if they do occur, they would do so only at very high energy scales.

AV: All of the work you've been describing—was it within the framework of Grand Unified Theories?

[1]See: **1**. Glashow, Sheldon L. "*The renormalizability of vector meson interactions.*" Nuclear Physics 10 (1959): 107-117.
2. Weinberg, Steven. "*A model of leptons.*" Physical review letters 19.21 (1967): 1264.
3. Salam, Abdus, and John Clive Ward. "*Weak and electromagnetic interactions.*" Il Nuovo Cimento (1955-1965) 11 (1959): 568-577.

[2]There are six quarks which make up the matter: up (u), down (d), top (t), bottom (b), charm (c), strange(s).

SR: Yes, all of that was within the framework of Grand Unified Theories. Now, of course, people do not focus only on Grand Unified Theories. The attention has shifted. I think many are working on quantum gravity.

I think in the late 1980s, string theory (a theory of quantum gravity) began to gain prominence—particularly because it aimed to unify not just the three gauge interactions but also gravity. Quantum gravity became more mainstream than GUTs at that point.

AV: You transitioned from working in theoretical high-energy physics to condensed matter physics. What motivated this shift, and how did it shape your overall research?

SR: That shift happened quite late, when I was a faculty member at the Institute of Physics in Bhubaneswar. During my postdoctoral years, I was still working in theoretical high-energy physics. At Stony Brook, my work was more phenomenological—closer to experiment. When I moved to Fermilab, I continued some of that phenomenological work, but also began engaging with more theoretical aspects of quantum field theory.

In particular, I worked on something called the topological Chern–Simons theory. That was part of what I did during my Fermilab years.

AV: How did you get interested in this?

SR: How I got interested in that was, again, as often happens—through others around you and what they are working on. A more senior faculty member or a senior postdoc can influence these directions. Some of the work was influenced by my office-mates.

As a Ph.D. student, you are typically given a project, but as a postdoc, you must look for your own projects and collaborators. At Fermilab, one of the researchers was working on topological field theories, so I started working with him. That's how I got interested in the subject. We discovered some interesting identities at the time, and while I moved on to other things, the work would become relevant again much later when I started working on the quantum Hall effect in condensed matter physics. At that time, that was the end of it, and then I started working on other things.

Once I came back to India, I started working on particles called *anyons*, which are intermediate between bosons and fermions. These anyons turned out to be connected to the quantum Hall effect, a subject in condensed matter physics.

"How I got interested in that was, again, as often happens—through others around you and what they are working on."

Earlier, in high-energy theory, my focus was on understanding particles as isolated objects. We would ask: what happens when two particles collide? How are particles created from the vacuum? These were the kinds of questions particle physics addressed. But quantum field

theory teaches you that the vacuum itself is not empty—it is a dynamical medium, more like a liquid with fluctuations. You might think of it as a sea with virtual particles bubbling in and out of existence. So even the so-called vacuum is a many-body system. It's not a single-particle theory. The kind of theories that are needed to describe even single particles are actually quantum field theories.

Condensed matter physics is basically about many-particle systems. The only difference now is that the total number of particles is finite. If you take a table, for example, it has a definite number of atoms. Whereas in high-energy physics, the vacuum can, in principle, support arbitrary numbers of virtual particles. So once you make the number of particles finite, the same kinds of quantum field theories can be applied to condensed matter systems.

So what happened was that many of these topological field theories started being applied also to condensed matter systems, like the quantum Hall effect. And then there was one of my fellow students from Stony Brook, *J.K. Jain*. He happened to be working on the fractional quantum Hall effect, and he came up with a new idea called composite fermions. And I saw those papers. I happened to see those papers through a reference in works by the very famous particle physicist *Frank Wilczek*. Since I knew J.K. Jain, I started reading his papers and found that they were interesting, very elegant and very nicely written. So that was how I transitioned from high-energy physics to condensed matter physics.

I should mention that after returning from the U.S., there were some years when it was quite difficult to find a conducive research atmosphere. We did not have the same ecosystem here that I had experienced abroad. For a time, I struggled to find meaningful projects. But in the long run, I found that condensed matter physics offered many interesting and feasible research directions.

PT: Continuing with your time at Fermilab—how was pursuing a postdoc in the U.S. Midwest for you?

SR: My postdoc years were actually quite difficult in the U.S., especially at Fermilab. It is not a university—there are no students there—and postdocs are the youngest, the lowest in the academic hierarchy. There are some other postdocs, of course, but not nearly as many as you would find at a university. And without students around, you are not part of a larger group—you do not have that anonymity that comes from being one among many. So it was difficult.

I was the only woman, and there were just a few Indians. We were in the Midwest—in Chicago—and we did not know very many people there. Until then, I had always lived a very 'student' kind of life—always in a group, always surrounded by friends.

At Fermilab, besides Ashoke and me, there was one more Indian student, *Sumit Das*. I had an office-mate, *Terry Leung*, who was from Hong Kong, China, and we became friends. But still,

Fermilab was very different from Stony Brook. It was a lot of hard work, and it was difficult to keep up with all the senior people, and even with the Indian postdocs like Ashoke and Sumit. They always seemed one step ahead. They found things easy—I did not. But that always happens, right? You always come across people who are better than you. So I had to work very hard. That is just how it was.

Until then, for me, work had been easy. That is the point. It always happens, I think—at some point, you hit your limit, and then you must push yourself.

PT: You have spoken before about how, during your time in the Midwest, your experience was shaped by both your gender and your background. While many Indians at the time may have felt out of place due to gender expectations in science, you have mentioned feeling doubly out of place—due to both your gender and racial identity. Could you tell us more about how that shaped your experience?

SR: Yes—wrong color and wrong gender. So I ended up extremely scared to speak up, and I always thought that I would say something stupid. So basically, I kept my mouth shut throughout those years. But then, you are also judged for keeping your mouth shut—that is the irony, right? I mean, you have to participate. Otherwise, you are judged. Yes, you are judged by your papers, of course, but you are also judged by how much you contribute to discussions. So it was difficult. Those were real difficulties. But yes, one learns.

"And then you realise that it's not that difficult, it is possible."

PT: You mention that you were always scared of saying something wrong or something stupid. That is something very prevalent among students, especially when transitioning from high school to a university environment or beyond.

SR: Yes, I was always very quiet. But until a certain point, you could get away with being quiet. I would only talk among peers or with close friends. Even at IIT, I was terrified to speak up in class, and I would never open my mouth. But it didn't matter much back then. At Stony Brook too, I didn't have to speak much publicly. I was very poor at giving seminars—at IIT, I was terrible at it.

But eventually, I had no choice—I had to give seminars. And then I had to give multiple seminars in order to get my next postdoc. Until the first postdoc, my advisor's recommendation was enough. But for the second one, I had to travel around and give 20 to 30 talks at different universities across the country. Those were really difficult times. But you have to do it—so you do it. And then you realise that it's not that difficult, it is possible. I mean, you have to give seminars, you have to answer questions that people ask you—it's not easy, but it's possible.

AV: So would you encourage younger students to participate in these activities as early as possible?

Sumathi Rao receiving the APS fellowship from Smitha Vishveshwara, chair of APS condensed matter division in March 2023. Sumathi Rao

SR: Yes, I would suggest to younger students that they participate as early as possible and get over their fears as quickly as they can. In my case, it happened very late.

AV: Because in academia, you're supposed to eventually do these things, right?

SR: Yes, exactly. You have to go around, give talks, defend your theories, ask questions—that's how research works. These things are difficult. I've had to speak with people, try to get involved in projects. When you are young, you have to be the one to take the initiative, to ask. In my case, because I wasn't doing that much, one of the senior people stepped in and asked someone else to at least check if I was interested in a project. So, at Fermilab, people did notice and help me out, but still, I had to do a lot more. That is eventually the learning experience.

DB: You have done your work in quantum transport and mesoscopic systems. What excites you most about this field today?

SR: Right now, what I work on is something called *topological quantum matter*.

Think of the difference between a donut and a sphere—that is the kind of distinction we are talking about. So, actually, what I work with involves such topological distinctions—like

knots and unknots, or two inequivalent knots. These are purely mathematical in origin, but they arise naturally in the systems we study.

In the kinds of materials I work on—these are materials, crystalline in the position space—what happens is that in momentum space, the wavefunctions of the electrons, say $\psi(k)$, belong to different topological classes. You can compute topological invariants like *Chern numbers* or winding numbers by integrating these wave-functions or functionals of these wavefunctions over the Brillouin zone[3].

Now, what people discovered is that the wavefunctions in momentum space can have non-trivial topological structure. Until around the early 2000s, people did not know that such topological phases even existed. In condensed matter, we were used to classifying phases of matter as solids, liquids, gases, magnets, etc., using Landau's theory. Landau gave us an entire paradigm where phases were described through spontaneous symmetry breaking and local order parameters.

But around 2000, people realized that there is a completely different way to classify matter—based not on symmetry breaking, but on topology. So in the last twenty years, this has led to a complete overhaul of what is now called the Landau paradigm. We now classify certain phases of matter by topological invariants rather than local order parameters.

Many standard materials turn out to be topologically trivial, but there exists a whole class of new materials which are topologically non-trivial. These are characterized by non-zero Chern numbers or winding numbers. So, metaphorically, instead of a sphere (which is topologically trivial), these materials are like donuts or tori—they carry such topological information.

Initially, these materials were predicted theoretically, and then later discovered experimentally. And now we know of many such topological materials. We have also realised that the quantum Hall systems are actually topological phases, but they need very strong magnetic fields and very low temperatures, whereas the new topological materials can be discovered or in fact, specifically designed. What is especially exciting is that in these new materials, we are not just dealing with electrons in the usual sense. Even though we're not talking about elementary particles, you still have quasiparticles—collective excitations—that behave differently. In fact, what people have found is that you can get fractionalized particles which are quasiparticles. The fractional quantum Hall effect was the first such phase to be discovered.

Now, in certain systems, people have started looking for Majorana modes—quasiparticle excitations that are their own antiparticles. These are extremely exciting because of their potential application to topological quantum computation. Right now, Majorana modes

[3] [SR] If you have a crystal, there is periodicity in real space. Because of that periodicity, when you go to momentum space—essentially a Fourier transform—the momentum values are quantized. So there are only a finite set of independent momenta and then the values repeat. This periodic momentum space is called the *Brillouin zone*.

are what everyone is looking for. Microsoft, for instance, has claimed they have observed them. They have announced something called the Majorana-based qubit, and published some of their work in Nature. But the community is still skeptical because their data is not fully reproducible, and being a private company, they cannot release all experimental details. Until at least one independent group reproduces their results, there will be doubt.

So that's where the field is now. These materials are exciting both for fundamental physics and for potential applications to quantum technology. Recently, I have also been looking into generalizations of Majorana modes—something called parafermions. That is what I have been working on lately. And yes, it is very exciting. Hopefully, some of these developments will soon enter the mainstream.

PT: How did your association with IUPAP begin? And what motivated you to get involved with its mission?

SR: Actually, I was asked by *Nandini Trivedi* from TIFR. She had been asked by someone she knew—*Judy Franz*—but Nandini was leaving India at that time and going back to the U.S.. She and her husband had stayed in India for a few years, and then they went back. She wanted someone from within India to try and collect feedback from Indian women physicists on whether they had faced any discrimination in their careers, and so on.

So, in my first round, I was asked to give a questionnaire to about thirty women physicists, and send that collection back to IUPAP. They were doing this globally—in all countries. So from India, I became the person who was asked. There was no systematic way of identifying anyone to do this—it just happened by chance. Since I knew Nandini, she asked me.

When we first gave this questionnaire, it was interesting to see that most of the women said that they hadn't faced discrimination in their careers up until then. Although each of them mentioned problems, they thought that it was personal to them. But this is not the kind of feedback you would get now, if you were to send out such questionnaires to women in India.

There have been many instances since then where people have said they've been discriminated against at various levels. But I think what happened in the early years was that there were so few women that we simply did not think about it, or thought it was personal to us. We just decided to ignore the sexist remarks, ignore the discrimination of any kind, and sort of blot it out. People in our generation also just assumed that casual sexism would happen—and we took it to be normal.

PT: So was there a committee appointed to send out the questionnaire and collect the responses?

SR: No, at that time, there wasn't. It was all self-organized. Nandini asked me, and I did it. Then I started talking to Neelima, Rohini [Godbole], and all these people—the whole Stony Brook gang. For the first IUPAP meeting, there was some ambiguity about who should go.

There were five people whom they could support from India, so they asked me to suggest names. Then they asked if there was anyone who could be considered a kind of "success story" from India, and I suggested Rohini.

It was all very informal in the first round because we didn't have an organization. I think we should have reached out to something like the *Indian Physics Association*, but none of us were even members at the time. So there really was no formal structure—it was just people talking to each other.

Now all these things are much more systematic. But back then, the number of physicists in India itself was quite low compared to today. There were very few research institutes in India at the time, right? Besides TIFR, there was IISc, then IMSC in Chennai, the Institute of Physics in Bhubaneswar, and HRI was new. Then there were the IITs, where a few people did research. And universities, where some research was happening—but not much. The newer IITs and the IISERs were yet to be established.

PT: Would you say that the idea for Lilavati's Daughters was somehow inspired by this initiative from IUPAP?

SR: When the IUPAP initiative came up, Rohini was at IISc at the time, and she was elected to the Academy of Sciences. They had decided to create a committee or a subgroup for women, and she became the president of that. Once she took over, things became much more formalized. I think she had a lot more clout—and she was already quite well-known in the field of particle physics. So she could get many more people involved.

By then, I was in Allahabad, which was quite far away from all this. So, the only way I was involved was by initially writing to people. After that, the main momentum shifted to Bangalore. I continued with IUPAP for a few more years, and then Shobana from Bangalore took over, and later Prajval Shastri. Gradually, many more people became involved.

In the first few rounds, we didn't even know how to reach out to people. I remember in the third round, someone from Tatanagar wrote to me, saying she was interested. The second meeting was held in Brazil, the third in South Korea—and then it really started to broaden. People from Delhi and other places also got involved. For the first meeting, which was in Paris, everyone's travel and stay were covered by IUPAP. But from the second round onwards, we had to write to various institutions and agencies to raise funds so people could attend. We especially wanted students to go, so that meant trying harder to arrange support. Once Rohini got involved with the Academy of Sciences, she was able to help. Many of the women did not have travel support and travel money, particularly younger ones.

PT: What does working as an editor in a research journal look like? Could you describe the duties and responsibilities of such a position, and how has the experience been for you overall?

SR: The duties and responsibilities of a Divisional Associate Editor (DAE) at *Physical Review Letters* (PRL) are quite specific. The day-to-day editorial operations are taken care of by the journal's staff. But the role of the DAE becomes important once a submission enters the peer review process.

Each submitted paper is sent to at least two referees for review. As a physicist, you regularly receive such referee requests yourself from various journals, so you know how the process works. The referees send in their reports, which are then forwarded to the authors. The authors respond to the comments, and there's usually a fair bit of back-and-forth—revisions, clarifications, rebuttals.

Now, when there is a conflict between the referees—say, two recommend acceptance and one recommends rejection—then the entire correspondence, including referee reports, author responses, and editorial notes, is escalated to the DAE. As the DAE, you have access to the identities of both the authors and the referees, although the referees remain anonymous to the authors. Your job is to carefully read through all the material and make a judgment: should the paper be accepted or rejected?

This is not always straightforward. You have to assess whether the referee comments are fair, whether there might be a conflict of interest, or if someone is being unnecessarily harsh. You have to evaluate whether the criticisms are scientifically justified or perhaps overly stringent.

In most cases, the decision made by the DAE is accepted by the editorial board. There is someone even above the DAE—an Editor-in-Chief—but in my six years in that role, I've never had a case go beyond me. The decisions I made were accepted, and the authors, even if unhappy, generally did not escalate further. And we also, as editors, normally try to uphold the referee's comments. Referees volunteer their time and thought, and we don't want to undermine that work. So unless a referee is clearly wrong, or being too demanding, we try to support their recommendations.

AV: Among your Stony Brook friends, I know that many, like Prof. Sunil Mukhi and Prof. Aparna Dar, have a deep interest in music. Do you also share that inclination? Do you listen to music regularly?

SR: Yes, I do listen to music, though not as seriously as them—Sunil and Aparna are very dedicated listeners. My engagement is far more modest. But my family has always been musically inclined. Both my parents played musical instruments—my father, who is no more, and my mother, who can't play anymore. But my mom is still terrifically interested in music, and that is probably what is keeping her in good spirits.

They were both very fond of Carnatic music—South Indian classical music. So, naturally, I grew up around it. When I was in Allahabad, I used to try learning classical music from a local teacher, perhaps once a week. And now that I'm back here in the South, I still try to

continue—though it's rather sporadic—through online classes with a teacher who is also a friend of my mom's. I do like to sing, although it has not been very consistent.

AV: Do you enjoy Carnatic or Hindustani classical music?

SR: When I lived in North India, I used to listen to and also try to learn North Indian classical music, but I would say that I like Carnatic music more. I also enjoy Hindi film songs. I like *ghazals*, *bhajans* and lighter music, but at the classical level, I much prefer Carnatic.

DB: Physics often demands sustained focus over long periods of uncertainty. How do you personally sustain motivation during times when results are elusive or ideas remain unresolved?

SR: I'd say that my motivation largely comes from the people I engage with—especially my students. I hang out a lot with my students, and they are very enthusiastic. That's what gives me my enthusiasm as well. In recent years, I've found that many of the questions they bring to me have become a primary source of my own curiosity and drive. That interaction keeps me engaged.

There are also a few topics—like Majorana fermions and other emerging areas—that naturally capture my interest. Topological quantum computation is also new and is something I am interested in. Even AI, machine learning—all these things are new and they interest me, at least to the extent that I want to understand what people are talking about. But to actually get to work on these things—it's really a lot of hard work, and that, I don't think I'd be able to do unless I have students around me who are motivated, who go deep into the nitty-gritties and ask me questions so that I'm forced to get into the details. If I were by myself, I think I would only do superficial reading.

Four academic generations: Sumathi Rao; her student P.K. Mohanty; his student Urna Basu (SNBNCBS, Kolkata); and her two students and her two students.
Sumathi Rao

DB: How was Bhubaneswar for you, and how was physics like back in the day?

SR: Bhubaneswar was where I started my career as a fully independent scientist, and I enjoyed my time there. It felt like a continuation of my student life. I used to interact mainly with PhD students at that time, not so much with the faculty, because I was staying in the student hostel—as they didn't have housing for me. So I continued staying in the hostel, along with

the students I used to teach, actually. I would take their classes, but I would also live with them. So in that way, it was a very different atmosphere from what most people have. Teachers usually live in separate quarters from students. Even in IITs, the teachers have their own housing, even if it's within the same campus—or in places like HRI. So in that sense, it was quite different.

I was still trying to figure out what I really wanted to do. At that time, I hadn't yet moved into Condensed Matter Physics—I was still doing High Energy Physics. Those were the years when I was trying to explore what direction to take, what would really interest me. The only thing I was sure of was that I did not want to do String Theory. In my final year in the U.S., I had also tried to learn String Theory because it was fashionable then.

"Some students tended to judge women faculty more harshly and wondered whether I was really confident about my lectures."

There were also some difficult aspects of being in Bhubaneswar. One issue was the people I met in Orissa at that time, who were mostly Bengali, and many of them had very strong opinions. They were more sexist than others I had encountered. They were not used to having women faculty members, and I was the first woman faculty there. So those kinds of issues did arise, and it made the initial years of teaching a bit difficult. I also wouldn't say I was very good at teaching in the beginning. I probably did not know the level at which I was supposed to teach, and so on. There were some very good students, some of whom became my best friends later. But I think some of the students also tended to judge women faculty more harshly and wondered whether I was really confident about my lectures and work.

But overall, except for one or two such negative elements, the experience was nice. It was also initially hard to get PhD students, because they had to trust a female faculty member to be able to guide them, and that took some time. So I think I got my first official PhD student quite late—just around the time I was moving to Allahabad—and he moved with me. That was *P.K. Mohanty*. He was very smart and has done really well. He became faculty at the *Saha Institute of Nuclear Physics* in Kolkata and is now a professor at IISER Kolkata.

Before that, a couple of other unofficial students had worked with me for their PhDs, but they were registered under other people. *Dattu Gaitonde*, who worked with *Prof. S. N. Behera*, had done a lot of his PhD work with me.

AV: Was Dileep Jatkar also your student? And what paths did your other students take?

SR: No—during his [Jatkar] PhD, four of his papers were with me, but he wasn't officially my student. He worked with *Prof. Avinash Khare* for his PhD, but we wrote papers together. He was very smart, and I was looking for people to collaborate with.
At that time, we were working on Chern-Simons theories. He [Jatkar] wrote four papers with

With collaborators and students. Includes Yuval Gefen, Ganpathy Murthy, Sourin Das, Arijit Kundu, Arijit Saha, Adhip Agarwala and others. Sumathi Rao

me during his PhD. But when he went to TIFR as a postdoc, he moved into string theory. *P.K. Mohanty*, my first official student who did his PhD with me, also went to TIFR for his postdoc. He switched fields as well—he started working with *Deepak Dhar* and others there. So he completely moved into statistical mechanics, a different area.

The first of my students who stayed in the same field I was working in was *Sourin Das*. He is currently at IISER Kolkata. He works on mesoscopic physics, and we continue to collaborate even today.
Actually, a lot of people I have worked with are now in IISER Kolkata—P.K. Mohanty, Sourin Das, and *Siddhartha Lal*, a student of *Diptiman Sen*, with whom also I have collaborated.

AV: So, the longest of your employment has been at HRI? What decision brought you there after Bhubaneswar?

SR: Yes, I was there for 25 years. The main reason was that *H.S. Mani* offered both me and Ashoke [Sen] jobs at the institute. At the time, we were living at two opposite ends of the country, but he brought us together—right in the middle—by offering us both positions. He was starting a new institute then, and that's what made the move possible. So yes, that was the main reason. It was called *Mehta Research Institute* back then.

AV: And how was Allahabad for you?

SR: Allahabad was fantastic for us—I loved it. That's where I spent all my working years, and we always felt that the Institute was ours. From the very beginning, we were there and were

involved in everything. There was a whole group of us—mostly in our early or late 30s—and together, we built the Institute from scratch. We started the graduate school, began teaching, even turned on the computers ourselves. The campus really became our life. We would often tell people, this is real India—you must come and visit here, not just Bombay or Bangalore or Goa.

So there's a deep sense of belonging and achievement—we felt personally attached to that place. And the students felt it too. Older students often say that what made HRI special was this sense of community. If you talk to any HRI alumni, they'll almost always say they think of the Institute as their home. Many of them would love to go back—they really loved their years there.

AV: Did you ever teach or have any employment at IIT?

SR: I have not taught at an IIT as a faculty member. But I have given colloquium talks at IIT Kanpur, and I have many friends there. One of my Master's students is now a faculty member at IIT Kanpur, and I know many people there. I like IIT Kanpur a lot.

AV: Do you like Uttar Pradesh as a state? Have you been to the Kumbh(s)?

SR: Many of us loved UP. We felt that this was where we belonged. And yes, of course—I've been to the *Kumbh*. HRI is located right on the Kumbh grounds. We attended the 2001 and 2013 Kumbh Melas, and the Ardha Kumbh in 2007 and 2019. We just missed the 1995 Ardha Kumbh.

AV: Oh! And the recent Maha Kumbh?

SR: No, not that one. It's become very commercial now. Back then, it was really lovely—we could just walk down from our institute to the Kumbh grounds.

There's something called the *American Physical Society* (APS) March Meeting, where around 10,000 people come together. It runs for a whole week, with several parallel sessions, from early morning till late at night. You go from session to session, talking to people—some sessions are excellent, some are quite bad—but there's always something going on. You just keep moving around, soaking it all in.

Usually, the Kumbh Mela used to be like that. I mean, there would be several tents, and there were people giving bhashans. You can call them talks, seminars, whatever you wish—they were about spiritual matters. Every tent would have some of these sadhus giving these seminars, and people would be sitting around, listening. Some tents would be extremely crowded—they reminded me of those APS meetings when graphene had just been discovered, and it had become the rage in physics. And then there were tents that were barely attended. But people would just be walking around, exploring everything.

A lot of those who came to the Kumbh were simple villagers, coming from different parts of

Sumathi Rao's artworks.
Left: An oil painting done in the 1980's. Right: A recent pencil sketch of a little girl.
Sumathi Rao

the country. In 2001 and 2013, it wasn't very politicized. So it was much, much nicer—more like a genuine gathering of people who simply wanted to witness and be part of something extraordinary.

AV: I believe the very original intention behind the Kumbh Melas was just that—a space for dialogue, correspondence, and debate.

SR: Yes. Now it's very different. But back then, it was really more of a spiritual gathering. I guess it was just fun to walk around and see the diversity—so many different kinds of people. Even in 2013, several foreigners came—even to HRI. We used to warn them: Don't come on the major bathing days—you won't be able to manage the crowds! I remember a couple—maybe from Israel—they showed up with their backpacks, walked through the entire mela, and came all the way to the Institute from the station, just like that.

PT: I was just curious—are there areas outside of physics, besides literature, such as philosophy or art, that inspire you or feed your creative thinking? I know you prefer oil paintings in particular. Could you tell us what makes oil painting so special for you?

SR: Actually, at Fermilab, when I was very frustrated with my work, I started going for some art classes—and in fact, I started going for oil painting classes—so that is one reason I got very interested in oil paintings. At that time, it was just for relaxation from whatever else I was doing, but what I found was that the teacher was good, and oil painting is easier than other kinds of painting because it is more forgiving. If you make a mistake, you can wait for a while

and paint over it, and you cannot make it out at all—you can change things and just wait and repaint. That was one reason I used to like oil painting back then.

But now, I actually do much more sketching than painting, because sketching takes less time, and sometimes you can finish it even in a day. But I do want to get back to oil painting, which maybe I'll probably do once I get some more consistent time. Since we have recently moved to Bangalore, it has been very busy. Relocating from Allahabad to Bangalore—with bag and baggage—took a lot of time.

When we were in New York during our PhD, we went to many of these museums in Stony Brook—the Metropolitan Museum, the Museum of Modern Art, the Pierpont Morgan Museum, etc. We would spend several weekends like that. This was part of the Stony Brook gang that I was talking about. We used to go to the city and see these things. And then later on in life, we got lucky, and we managed to stay in Paris for a year on a sabbatical—I think it was in 2000—and then we travelled around in Europe. We witnessed a lot of this really fantastic art. In Europe, when you go around, you see that it's not just the museums—sometimes even the old buildings, the churches—many of them have beautiful art on them.

PT: The architecture there is art in itself, actually.

SR: Exactly, yes! The architecture there is art in itself, so you really get interested in that.

I think, as a kid, I was always interested in drawing, but I never took it seriously—never thought I could actually do it—until my postdoc years. So each of these things has its own reason. I think music, art, and all these things often offer an escape from your work when things are not going well, but then they also become interesting in their own right.

PT: We often ask what advice you would give to the younger generation, but instead, may we ask: what is one piece of advice you think they should not take?

SR: I think one thing you should stay away from is people who tell you, "This is what you should do to get ahead," or "Go do this to be successful." Because when somebody gives you advice on how to become successful—or whatever they say—they're actually defining success for you, and that just shouldn't be done. So I think you should stay away from anybody who tells you that this is the way to do things.

I mean, you should find your own way to do things, and you should find your own meaning—you should define your own success. In simple words: **don't allow someone else to define success for you**.

This interview was conducted remotely over a virtual meeting platform.

Interview

In the Lineage of the Eternal Note: Interview with Jyoti Hegde

Jyoti Hegde playing Rudraveena. Jyoti Hegde

Jyoti Hegde is an Indian classical musician, known for her mastery of the Rudraveena in the Dhrupad tradition and her artistry on the sitar. Vidushi Hegde holds the distinction of being the first Indian woman to play the Rudraveena. A disciple of Dr.Bindu Madhav Pathak, Pandit Indudhar NirodyJi of the Agra Gharana, and Ustaad Asad Ali Khan Sahab, she represents the Khandarbani lineage of the Dhrupad tradition. She is the founder of *Veenagram*, a Gurukul rooted in traditional musical pedagogy, located in Sirsi, Uttara Kannada. This interview carries discussion with Vidushi Hegde on various such life events.

It is a great honor to interview you for Anveshanā. We must admit, we are a little nervous speaking with you—the first woman to play the Rudraveena. May we begin by asking about your early years? Was there an artistic atmosphere in your household? And how did you come to choose music among the various forms of art?

Jyoti Hegde: It's humbling to be part of a lineage where the Rudraveena holds such deep reverence, and I understand your nervousness—but I see myself simply as a seeker on this path.

To answer your question, there was no formal background of music in my family. However, my father played a crucial role in sowing the seeds of my musical sensibility. As a child, he would make me sit and listen to *Aakashvani*, and the voices of great maestros would fill our home. I was brought up on the music of legends like *Vidushi Gangubai Hangal, Pt. Bhimsen Joshi, Mallikarjun Mansur Ji*, and many others. Those early listening experiences became the foundation of my inner musical world.

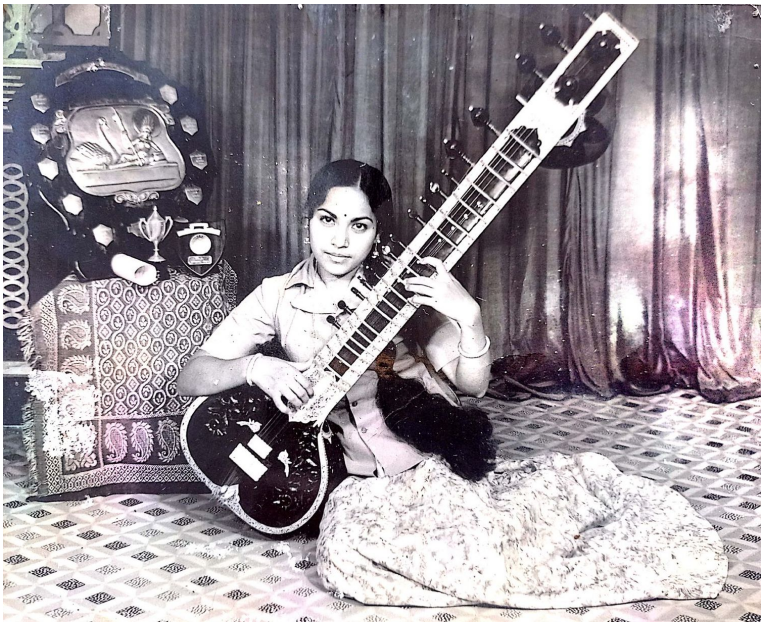
Interestingly, music came into my life quite coincidentally—as a subject I chose at university. Until then, I had excelled in various fields like sports and dance. But once I stepped into the world of music at the age of 16, it felt like everything else gently faded away. Music didn't remain just a subject—it became my calling, my passion, and eventually, the very axis around which my life began to revolve. I began my musical journey with the Sitar, which gradually paved the way to the Rudraveena. This was a transition that became the true turning point of my life.

Jyoti Hegde with her parents. Jyoti Hegde

It was quite rare, back then, for a woman to choose music, let alone Rudraveena. Could you tell us about Rudraveena and its spiritual significance? What were the prejudices, if we can call it that, against women choosing this instrument?

JH: People often describe the journey of pursuing an art form—especially a rare one- as a struggle. But I've always felt that when you truly love something, even the greatest inconveniences feel tiny. For me, the desire to learn the Rudraveena was so strong, so deeply rooted, that what others may call "struggles" became simply a part of my path- a meaningful journey in itself. Like any journey, it had its straight roads and unexpected detours. When I took up the Rudraveena, I had no idea that I was possibly the first woman to do so. Nor did I ever feel the need to claim such a title. To me, the instrument never asked who was playing it—it only responded to sincerity and passion. There is nothing about the Rudraveena that a woman cannot play. When the urge to learn is genuine, gender becomes irrelevant. What matters is dedication.

The Rudraveena holds profound spiritual significance. Its deep, meditative resonance naturally invites stillness and introspection. Historically, many seekers have used it as a tool for their own spiritual practice, or *sādhana*. In fact, that very quality is what allowed the veena to find its place in the Dhrupad tradition, which is itself deeply rooted in devotion and inner exploration.



Jyoti Hegde with Sitar. JYOTI HEGDE

You had been practising in Sitar before Rudraveena. How and why did you refocus and choose Rudraveena? Moreover, what are the differences between the two instruments, and in which of the two do you find more inspiration?

JH: It was purely by chance that I first encountered the Rudraveena, that I was already learning the Sitar at the time and had no idea that my Guru also played the Rudraveena—until I saw him perform it at a college program. That moment changed everything for me. It was the first time I heard the sound of the Rudraveena, and I was instantly captivated. The sound lingered in my mind—it was haunting, profound, and unlike anything I had experienced before. I didn't think twice; I knew I had to learn it. I requested my Guruji to teach me, but it took a great deal of convincing and, of course, a test of my sincerity before he finally agreed. The journey from there is something I've spoken about in many of my earlier interviews—but that moment, that encounter, was truly the turning point.

As for comparing the Sitar and the Rudraveena—it's not quite fair, because the Rudraveena is, in fact, the ancestor of the Sitar. They belong to different eras and traditions. Technically, they are very different instruments, each with its own *swabhāva*— or inherent nature. The Sitar is graceful and versatile in its own right, but I found my true voice in the sound of the Rudraveena. The Rudraveena has a deeply meditative quality. Its resonance carries both masculine strength

"It was the first time I heard the sound of the Rudraveena, and I was instantly captivated. The sound lingered in my mind—it was haunting, profound, and unlike anything I had experienced before."

and feminine grace. My Guru, *Ustad Asad Ali Khan Sahab*, once beautifully described it as 'embodying the essence of *Ardhanārīśvara*—a perfect balance of the masculine and the feminine'. That description resonates with me deeply. The Rudraveena has everything my soul seeks—it is not just an instrument to me, but a spiritual companion. Looking back, I believe that moment when I first heard it wasn't just an artistic choice—it was a destined call.

Who were your gurus around your blooming period? How did they help you in becoming one with the music that you chose? Were they always from Dhrupad?

JH: My musical journey began under the guidance of *Dr. Bindu Madhav Pathak*, who was my first Guru. It was with him that I started learning the Sitar, and it was also under his tutelage that I was first introduced to the Rudraveena. For a few formative years, I absorbed training in Khayal style and the Rudraveena's stylistic elements from him. Though his background was rooted in the Khayal tradition, his approach laid a strong foundation for my understanding of melody, discipline, and musical aesthetics. Later, I was introduced to the Dhrupad style, which brought a significant shift in my musical perception. I began learning the basics of Dhrupad under *Pandit Indudhar Nirody ji* of the *Agra Gharana*. He opened the door to this profound tradition for me. To deepen my understanding and refine the nuances of the Dhrupad style, I then came under the guidance of the legendary Ustad Asad Ali Khan Sahab, one of the greatest Rudraveena players in the *Khandarbani* tradition. Each of these Gurus has played an irreplaceable role in shaping who I am as a musician. Their contributions are immeasurable, and I carry their teachings with deep reverence.

Jyoti Hegde with her guru Dr. Bindu Madhav Pathak.
Jyoti Hegde

In Indian classical music, the Guru is more than a teacher—they are the light that shows the path. While not all of my Gurus came from the Dhrupad paramparā, each one brought unique insights and dimensions to my learning. Together, they helped me become one with the music I eventually chose as my life's path.

What is the importance of a guru in music, art, or simply life? Does there always exist one (or more)?

JH: In music, or in any art form, a Guru is very important. A Guru doesn't just teach you techniques—they help shape your thinking, your discipline, and your connection with the art. They guide you not just in music, but in life too. In my journey, every Guru I've had has come at the right time and helped me move to the next stage. Each one has taught me something

Jyoti Hegde with her guru Ustaad Asad Ali Khan. JYOTI HEGDE

different, and I carry their teachings with me every day. I do believe that everyone has one or more Gurus in life— sometimes in the form of a teacher, and sometimes as an experience or even a moment that changes you deeply. A Guru can take many forms, but their presence is always special.

What was your first ever public performance? Do you remember the hour? How does an artist think before appearing in public for a performance? Is she nervous, or is she inspired mostly? Or is she sometimes clueless about what may happen? And, what is your ritual before performing?

JH: My first ever public performance was a very special moment, but honestly, I don't remember the exact hour. I was performing for the *Yuva Vani* program organised by *Aakashvani*—it was my debut. What I do remember clearly is the feeling before stepping on stage. As artists, before a performance, our mind enters a very different space. It's calm, focused, and deeply connected with the raaga we are about to present. Ideally, it should be a meditative state—free from distraction and noise. In the green room, I usually stay silent. I prefer not to talk or meet anyone before going on stage. I just stay with the music—mentally tuning into the raga, going over the feel of it, and absorbing its mood. Yes, sometimes there is nervousness, sometimes inspiration flows strongly, and sometimes we really don't know how the performance will unfold. But that uncertainty is also part of the beauty—it keeps the experience real and alive. For me, my only ritual before performing is silence, and being completely with the music. That's where I find my grounding.

You became a disciple of Ustad Asad Ali Khan Ji in the Khandarbani gharana of Dhru-

pad. What is the meaning of 'gharana' in music? And what about the Khandarbani gharana in Dhrupad made you follow it?

JH: A gharana in Indian classical music is like a musical family or a school of thought. When you become a disciple of a Guru, you naturally become part of that musical family—one that carries a certain style, a certain way of understanding and expressing music. Over generations, when a particular style is passed down, shaped, and nurtured, it forms a tradition—that's what we call a gharana. It becomes like a musical signature. But even within the same gharana, every musician's style is unique because music reflects who you are. Your personality, your emotions, your inner world—all of that comes through your music. So while two artists may belong to the same gharana, they might still sound very different.

Ustaad Asad Ali Khan with Rudraveena
©Wikipedia Commons

When I went to learn from Ustad Asad Ali Khan Sahab, I honestly didn't know he belonged to the Khandarbani tradition of Dhrupad. I was simply drawn to his style of playing—it moved me deeply. I didn't go looking for a specific gharana, I just wanted to learn from him. Later, I came to know that his playing belonged to the Khandarbani of Dhrupad. What drew me in was the balance in his music—it had power, but also a beautiful emotional depth. He often said that 'music should be like a sea of emotions, and it's up to the artist to choose which wave they want to bring to the surface'. That idea stayed with me. His thoughts about music, about the instrument, and about expression really touched me. That's what made me fall in love with the Khandarbani style of playing the Rudraveena—it felt honest, deep, and complete.

How was learning from a great exponent of Rudraveena, Ustad Asad Ali Khan Ji, for you? Who else was learning under him at that time? How was his teaching, and do you remember any anecdotes to share with us about Khan Sahab?

JH: Learning from Ustad Asad Ali Khan Sahab was a completely different experience compared to learning from my other Gurus. For one, there was a big geographical gap—he lived in New Delhi, and I was in Karnataka. In the beginning, this made things a little difficult, so Khan Sahab suggested that whenever he came down south for concerts—in Bangalore, Mumbai, or anywhere nearby—he would call me, and I could travel to him with my Veena and an escort. So, a lot of my taalim happened in hotel rooms, green rooms, or wherever he was staying. I learned from him like that for nearly seven years. It was not just formal training—it was a complete experience. I got to see his lifestyle up close, his way of thinking about music, and his strong connection with tradition.

"His music had that kind of power—you may not understand it intellectually right away, but your soul knows."

Khan Sahab came from a royal musical lineage, and that reflected in his presence, his discipline, and the way he carried his music. His command over the Rudraveena, over raaga, and over language was something I deeply admired. He didn't just teach notes or compositions—he taught how to live music, how to carry yourself as a musician. There are many small memories that I carry with me—like the way he would describe a raaga not just through notes but through emotions, or how he would say that music must have a sense of royalty and grace. It was not just learning; it was growing in his presence.

Khan Sahab had wonderful interpretations of Raagas. How did you inspire yourself? When did you start interpreting raagas on your own? Morever, did you understand Khan Sahab's bhakti rasa and the divine call very early?

JH: Khan Sahab's way of looking at a raaga was truly unique. It wasn't just about the structure or notes—it was about emotion, mood, and presence. Every raaga had a soul in his hands. I remember how, when he played *Kanada* or *Malkauns*, there was such a powerful masculine energy in the music. It would feel like a deep, grounded force. And then, when he played something like Khamaj or Bihag, he would shift completely—his playing would become gentle, graceful, full of sweetness. That ability to bring out the true rasa of a raaga, and to switch so naturally between masculine and feminine energy—that was something I admired deeply.

Ustad Asad Ali Khan and Jyoti Hegde. Jyoti Hegde

At that time, I don't think I understood everything consciously. I didn't fully grasp the bhakti rasa or the divine aspect of his music in words. But I felt it. It moved me deeply. His music had that kind of power—you may not understand it intellectually right away, but your soul knows. As for my own journey of interpreting raagas—that came slowly. For a long time, I simply absorbed. I didn't try to interpret—I just listened, practiced, and stayed close to the music. But gradually, something shifted. I began to feel the raaga not just as something to play, but as something to converse with. I think that's when my own interpretations began. They were not imitations anymore—they became reflections of how I felt inside. Khan Sahab's influence stays with me even now. His deep connection with emotion, his understanding of the divine call within music—that's something I still carry, and continue to grow into.

What gravity does music have in terms of traditions, spirituality, and divinity? Somebody—like you, who immerses themselves in music spiritually, how does the world become for you?

JH: Music, for me, is not just sound—it is a way of living. It carries deep tradition, because every note we sing or play comes from a long line of masters who kept this art alive with dedication and love. That connection to tradition itself brings a sense of grounding. Spiritually, music is like a path. When I'm fully immersed in it, it feels like prayer. There is silence, peace, and something that connects me to a space beyond the everyday world. It helps me go inwards and also upwards, towards something divine. When I am in that space, the outside world fades away. There is no noise, no rush—just the music and me. In those moments, the world becomes quiet, full of beauty, and everything feels more meaningful. Music becomes a bridge between me and something greater.

You have mentioned elsewhere that during the Mughal period, the Khayal tradition became more apt for performers in the courts, which led to more use of sitars. In comparison, the Dhrupad style benefited the Rudraveena, which unfortunately had a slow run after its golden period. How do these political events shape the music, the listeners, and the performers?

"The Rudraveena has everything my soul seeks—it is not just an instrument to me, but a spiritual companion. Looking back, I believe that moment when I first heard it wasn't just an artistic choice—it was a destined call."

JH: Yes, political and cultural shifts have always had an impact on the arts, and music is no exception. During the Mughal period, the atmosphere in royal courts began to favour styles that were more decorative and expressive in a lighter way. That's how Khayal started gaining popularity—it allowed more freedom in presentation, and it suited the taste of the courts. Instruments like the Sitar, which are more versatile in that context, naturally found more space.

On the other hand, Dhrupad is deeply spiritual and meditative. It was always more connected to temples, royal patronage of a different kind, and personal *sādhana*. Rudraveena, being very introspective and subtle in sound, was ideal for Dhrupad. But as court music moved towards performance-based forms, the Rudraveena started to fade from the public stage. These changes affect not just the music, but also the audience and the artist. Listeners began expecting a different kind of experience— something more immediate, more dramatic. Performers had to adapt, and many shifted towards what was in demand. But I believe that every tradition has its time, its cycles. The spiritual depth of Dhrupad and the Rudraveena can never disappear. They are like quiet rivers—always flowing, even if not always seen. And now, slowly, there is a growing respect again for that kind of depth and stillness in music.

In your opinion, what is the role of patience and discipline in mastering Indian classical music?

JH: In my opinion, patience and discipline are essential to master Indian classical music. It requires years of consistent practice, dedication, and an openness to learning. Even when you feel like you're close to the goal, you realize that there is no final destination. Music is not something you "achieve"; it's a never-ending journey. To truly walk this path, regular practice is key. It's not about attending classes once in a while—it's a way of living, a continuous process. Indian classical music isn't a hobby; it's a discipline that shapes your entire life, every day. The journey itself becomes the destination. Nowadays, I often find students coming to me and telling me what they want to learn next, which is quite amusing because traditionally, it's the guru who decides what to teach and when. It's important to remember that learning music requires patience. You think you've reached a certain level, but then you realize there are countless more steps to take.

Every time you feel like you've reached a peak, you discover that there's an even higher one waiting for you. This is why patience is so crucial. Art, especially music, is a subtle thing. It involves understanding minute details and abstract ideas of beauty that can't be rushed. The student needs to understand that it's not about quickly reaching an endpoint, but about experiencing the journey and growing with it.

Jyoti Hegde with Rudraveena. Jyoti Hegde

Do you think there are multiple myths about music among people? There are many, for instance, about Rudraveena and women. We can guess it is mostly because of power dynamics and our population not being educated in music. How do you think we can combat these?

JH: Yes, there are certainly many myths about music, especially around instruments like Rudraveena and the role of women in classical music. Some of these myths come from outdated power dynamics, social structures, and a lack of understanding about the true nature of music. Rudraveena, for example, has often been seen as a "masculine" instrument, which is a misconception. Music itself is beyond gender, and anyone with the passion and dedication can connect with any instrument, regardless of gender. Another myth is that classical music, especially the deep spiritual traditions like Dhrupad, is only for a select few or those with specific backgrounds. This limits people from understanding its universal appeal and beauty. The lack of widespread education in music

also contributes to these misconceptions, as people are often not exposed to the depth and versatility of classical music.

To combat these myths, education is key. We need to create more opportunities for people to learn about music—not just in schools but in communities, through media, and public performances. Educating people about the rich diversity and inclusivity of music can break down these barriers. The more people see women performing on instruments like Rudraveena, or hear the depth of Dhrupad, the more myths will fade. Additionally, fostering open discussions and encouraging women to take up all kinds of instruments, including ones historically dominated by men, will help change perceptions. Music, at its core, is about expression and connection, and it should be free from the constraints of myths and stereotypes.

Moreover, music has become a daily consumption among the masses. However, mostly new music - hip-hop, rock, and so on. What do you think distinguishes classical music from other forms of music, especially the systems of music that have emerged recently?

JH: Classical music, especially Indian classical music, is fundamentally different from newer genres like hip-hop or rock—in its depth, structure, and purpose. While modern music is often created for entertainment and instant enjoyment, classical music— both in its creation and listening experience—demands a deeper level of immersion. Indian classical music, for example, is based on intricate systems of *raagas* and *tālas* that are designed to evoke specific emotions and connect with the listener on a different level. The process of learning classical music is long, requiring years of disciplined study to understand the nuances and subtleties of rhythm, melody, and expression. The emphasis is on depth, connection, and an almost meditative experience, rather than quick consumption. In contrast, popular music today is designed to be more accessible and consumable in a short amount of time. It focuses on catchy rhythms, lyrics, and immediate gratification. Genres like hip-hop and rock have their own energy, creativity, and cultural relevance, but they don't have the same structure or emotional depth that classical music carries. What truly distinguishes classical music is the journey it offers. Every note, every phrase is a story waiting to unfold, and it's not about a quick fix—it's about cultivating a lifelong relationship with music. The system of improvisation in Indian classical music, for example, allows for a personal expression of emotion and spirit, where every performance can be unique and deeply personal. In short, classical music is about a deeper, more thoughtful connection to sound, while modern genres cater to more immediate emotional or social responses. Both have their places in the world.

"Music, at its core, is about expression and connection, and it should be free from the constraints of myths and stereotypes."

Tell us about your students. How did they find you? How do you choose students?

What is the most important lesson you give them about music?

JH: I currently have about 45 students from all around the world, and they come from different backgrounds and regions. It's wonderful to see them progressing and doing well. I have a Gurukul named Veenagram where we all live together. When someone approaches me to learn Rudraveena, I always make sure to be upfront about the challenges of the instrument. I tell them that it's a long-term commitment, and if they're not ready to fully dedicate themselves, it might not be the right time to start.

Disciples paying respect to their guru Jyoti Hegde.
Jyoti Hegde

Once you pick up the Rudraveena, there's no turning back. Some of my students dedicate all their time to the instrument, while others balance it with their professions. But what's encouraging is seeing the younger generation take an interest in it. I'm confident they will carry forward the legacy of this art form even better than we have.

As for my teaching methods, they vary from student to student. Each individual has their own pace and way of learning, so it's important to adapt the approach to suit their unique needs. A good teacher recognizes that every student learns differently, and the way they absorb knowledge will reflect back on the teacher. So it's important to be flexible and patient in guiding them. You cannot have the same method for everyone. I often lightly say, some have a habit of catching a flight while some enjoy the pace of a bullock cart. Both are fine in their own ways!

Are there any memorable performances that you have done? Where were they and why are they close to you?

JH: There have been many memorable performances, but one that stands out is my performance at the *Darbar Festival*[1] in London. It's not just about the place; it's about the entire experience—the sound system, the ambiance, and of course, sometimes it's also about the listeners. Darbar Festival has the best sound system I've ever encountered, which is rare to find in India. What makes it even more special is the listeners—they are so knowledgeable about music and aware of what's happening on stage. This creates an environment where the artist can truly connect and perform at their best. The arrangements at the festival are also

[1]Darbar Festival is currently the most prestigious platform of Indian Classical Music that happens once in a year in London. Performed in 2014 (https://youtu.be/qGutd8VAUec?si=WAPaRirVEMN2ciGZ) and 2023 (https://youtu.be/PfiEPZE9w7M?si=INDwSl80NsMa02SG).

Jyoti Hegde with Rudraveena. Jyoti Hegde

incredibly well-organized, which allows the artist to focus entirely on their performance. I had a truly memorable experience there, not just in 2016, but also during my recent performance in 2023. It was a space that allowed me to immerse myself fully in the music, and that's what made it unforgettable.

Have you ever performed in Kanpur?

JH: Yes I have performed in Kanpur on numerous occasions—so many, in fact, that I've forgotten a few of them. However, I clearly remember my first concert there, which was organized by IIT Kanpur, though I don't recall the exact date. I have also performed a jugalbandi performance with *Shri Satish Chandra ji* on the sitar—a Sitar-Rudraveena duet—in the year 2020. Another performance I recall was in 2018, for the College of Management Studies, Kanpur. These are just a couple of the concerts that come to mind.

There is a connection between Yoga and music, which you have often expressed. Could you tell us more about this, Sangeet Sādhana, Naradeeya Shiksha (on which we believe you have worked), that is required for a musician?

JH: I truly believe that yoga and music are deeply connected, especially when it comes to playing Rudraveena. When I started learning with Ustad Asad Ali Khan Sahab, I discovered the powerful link between yoga, specifically pranayama, and playing the Rudraveena. The instrument's close connection to the body is unique—when you hold the Rudraveena (traditional style of holding Rudraveena), it rests directly on your body, and your breathing patterns directly affect the sound you produce. To play it properly, you need to maintain a steady, calm breathing pattern, and that takes practice. This is where the practice of yoga comes in. The

discipline and control over your breath through pranayama and Omkar sādhana are vital for mastering the Rudravena. Yoga helps you connect deeply with your instrument and control your breath, which is essential for producing the best sound. It's a different kind of sādhana that supports the journey of a musician, especially in traditional styles like Rudraveena.

We know and realise that music holds a very special place in your life, but besides it, do you also practise some other hobbies or any other form of art?

JH: In my childhood, I learned Bharatnatyam and was quite good at painting. But when music entered my life, it became my sole focus. However, these days, I have many other hobbies that I enjoy. I'm involved in farming and gardening, and I still find time to paint occasionally. I manage everything by myself at home. We have a large orchard of arecanut, and we also plant black pepper, cardamom, and a variety of other spices. Each year, we grow sweet corn, which my students enjoy, and I love experimenting with different recipes. These hobbies keep me grounded, fresh, and connected to nature, which indirectly helps me stay in tune with my music.

We, at Anveshanā, aspire to encourage a needful attention between different forms of scholarships. Be it music or sciences, we often have a required aim to find the meaning of our life in these disciplines. But many times, people struggle with all sorts of things. In concluding thoughts, please tell us about how one should aim to bring life to its meaning (in whichever discipline). Moreover, do you wish to give any suggestions to young people who are pursuing music?

JH: To bring life to the meaning in any discipline, be it music, art, or any other form, it's essential to dive deep into its essence. The true meaning lies not just in the technique or the end result, but in the process itself. One must understand the purpose behind their work, connect emotionally with it, and constantly evolve. In music, this means not just learning the notes, but understanding the emotions, the culture, and the tradition behind the sound. You must not only perform, but live the music, breathe it, and let it transform you.

"To bring life to the meaning in any discipline, be it music, art, or any other form, it's essential to dive deep into its essence. The true meaning lies not just in the technique or the end result, but in the process itself."

For young people pursuing music, my advice would be to stay patient and dedicated. Music is a lifelong journey and it's okay if it takes time to truly master it. Don't rush. Be open to learning from everyone, especially from maestros. Cultivate discipline in your practice and remember that setbacks are part of the journey. Also, never forget to enjoy the process. It's not just about the destination but the beauty of the path you take along the way. Keep your mind open, and stay curious—music will teach you more than you can imagine.

This interview was conducted over email correspondence.

Article

Musings Around the Hyphen in Harish-Chandra

by C.S. Aravinda

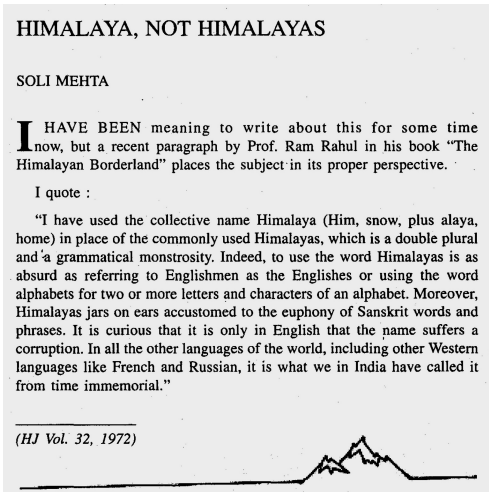
The circumstances leading to the occurence of hyphen in the mathematician Harish-Chandra's name has been written about.[1] The focus in this note is not quite Harish-Chandra, but certain linguistic aspects of the name and how this hyphening happenstance sits well with the finer nuances of Sanskrit.

> *What's in a name? That which we call a rose by any other name would smell as sweet.*

This line appears in the celebrated play *Romeo and Juliet* by William Shakespeare, in which Juliet regards the name as a label—a mere identifier rather than an essential part of the person, Romeo, who stands before her.

Person and persona are two different perceptions. A name may convey ethnic origins, but it seldom reveals the full character or inner identity of the person.

Be that as it may, the name 'Harish-Chandra' in formal forums as well as in publications, and 'Harish' in informal addresses by his family and friends have a revealing ring to them, particularly so when pronounced. The 'i' in 'Harish-Chandra' in standard pronunciation in the Indian context is a short syllable, that is, 'i' as in 'Himalaya'. Whereas, pronounced separately, the 'i' in 'Harish' is a long syllable, 'i' as in 'Pizza'.



HIMALAYA, NOT HIMALAYAS

SOLI MEHTA

I HAVE BEEN meaning to write about this for some time now, but a recent paragraph by Prof. Ram Rahul in his book "The Himalayan Borderland" places the subject in its proper perspective.

I quote :

"I have used the collective name Himalaya (Him, snow, plus alaya, home) in place of the commonly used Himalayas, which is a double plural and a grammatical monstrosity. Indeed, to use the word Himalayas is as absurd as referring to Englishmen as the Englishes or using the word alphabets for two or more letters and characters of an alphabet. Moreover, Himalayas jars on ears accustomed to the euphony of Sanskrit words and phrases. It is curious that it is only in English that the name suffers a corruption. In all the other languages of the world, including other Western languages like French and Russian, it is what we in India have called it from time immemorial."

(HJ Vol. 32, 1972)

A note that appeared in the *Himalayan Journal*, pointing to a commonly committed error in English. Courtesy of C.S. Aravinda

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[1] See page number 204, of "Harish-Chandra, 11 October 1923 – 16 October 1983", by Robert Langlands in the *Biographical Memoirs of Fellows of the Royal Society* Volume 31, Nov 1985; and https://bhavana.org.in/harish-chandra-making-of-the-mathematician/

While the formal and informal versions of the name in question here both indicate his origin from India, there are certain overtones to the words themselves, such as the nuance of the short and long syllable pronunciation of the letter 'i'.

Just the name Harish-Chandra, without the initials or an added qualifying last name suffix, does not quite give any clue as to which part of the large country of India he is from. But the two words Harish and Chandra, connected by a hyphen and pronounced together, tell an entirely different story.

In its more familiar conjoined form, and typed in roman script as Harishchandra, and googled, the popular Wikipedia page- `https://en.wikipedia.org/wiki/Harishchandra`- tells the story of a king by that name, seen as an epitome of truth in Indian mythology, appearing in several classic source works including the great epic poem Mahabharata; the particular part in the Wiki page reports "In Mahabharata, Narada tells Yudhishthira that Harishchandra is a rajarshi (king-sage), and the only earthly king who finds a place in the assembly of gods."

The story of the king Harishchandra from the legends is so widely celebrated in the seemingly endless cultural fabric of India from historic times that it is retold with all its composite subtle nuances in epic poems in several prominent languages of India.

While the alluded Wiki page is a metaphoric rabbit hole of a world of information, enticing anyone into a standalone exploration, one thread, of some relevance in our context, is in a section titled "In popular culture". It opens with the sentence "Poet Raghavanka's *Harishchandra Kavya* from 12th century in Kannada language is a very popular and acclaimed epic on the life of Harishchandra".[2] The extent to which this story is perpetuated from time immemorial, so to speak, is reflected in these lines from the same page: "The Kannada movie *Satya Harishchandra* was based on 12th century Hoysala poet Raghavanka's work, starring Rajkumar.[3] The film was awarded the President's silver medal for the Best Feature Film in Kannada, and was hugely successful at the time of its release, and is seen as a milestone in Kannada cinema."

Of particular relevance of the story that one gleans here is the prefixed word *Satya*, literally meaning 'truth' in Sanskrit, to the name Harishchandra, which describes his steadfast adherence to 'truth', even in the face of grimmest of situations. The testing circumstances driving him to end up as a guard at the entrance of a cremation ground, he would not let his destitute wife, once queen Chandramati, take the cadaver of their son Rohitashva, died of snake bite, inside without paying the necessary fee. It is at this moment, as legends tell the story, that the gods decide that the earthly king has earned a worthy a place in the heaven.

Going beyond the legends, and delving a bit into the etymological origins of these words them-

[2] A translation of this nearly millennium old classic into English is published by the Harvard University Press in their Murty Classical Library of India series https://www.murtylibrary.com/books/the-life-of-harishchandra.

[3] By popular accounts, arguably the most iconic actor in the history of nearly a century old Kannada film industry.

selves, one can trace the word Harish, or Harisha in Sanskrit, as being formed by combining two words *Hari* and *iśha*, meaning 'ray' and 'lord'. Taken together they come to mean 'lord of the rays', which primarily connotes either the sun or the moon. Interestingly, the word 'hari' has as many as fourteen distinct meanings, rendering it open to all kinds of interpretation. One of its meanings is 'ray' (*Amarakośa*, 3.3.175),[4] which leads one to interpret the meaning of 'Harisha' as mentioned above.

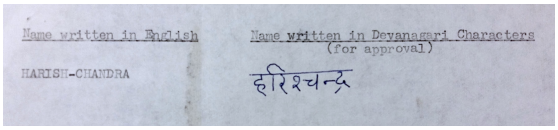
As a Sanskrit word, 'Harishchandra' is made up of two units: *Hari* and *chandra*, with additional 'sh' sound emerging when the two component words get together in a compound, governed by a rule in the system of Paninian grammar (*Aṣṭādhyāyī*, 6.1.153). Monier-Williams' *Sanskrit–English Dictionary* gives the meaning of the word harishchandra (*hariścandra*, in the International Alphabet of Sanskrit Transliteration scheme) as 'having golden splendour'.[5]

-ścandra (*hári-*),
mfn. (see *candra*) having golden splendour, RV.; m. N. of the 28th king of the solar dynasty in the Tretā age (he was son of Tri-śaṅku, and was celebrated for his piety; accord. to the Mārkaṇḍeya-Purāṇa he gave up his country, his wife and his son, and finally himself, to satisfy the demands of Viśvāmitra; after enduring incredible sufferings, he won the pity of the gods and was raised with his subjects to heaven

Courtesy of C.S. Aravinda

Interestingly enough, as regards the hyphenated version, a standard way to indicate the joining of two Sanskrit words into one compound word, when written in the Roman script seems to be, to put a hyphen where the joining happens. For example, the joining of *Chandaḥ* and *Sūtram* would be written as *Chandaḥ-Sūtram*. Thus, such a joining of the words 'Harish' and 'Chandra' into a compound word will be 'Harish-Chandra', but in this conjoined form, the pronunciation stress on the syllable 'i' automatically switches to the short mode.

It is tempting to ask if Harish-Chandra was actually aware of this. There is an apparent evidence supporting that this may indeed be the case, because there is no change in the way he wrote his name in the Devanagari script before and after his change to the hyphenated version in the Roman script.


Name written in English
HARISH-CHANDRA
Name written in Devanagari Characters
(for approval)
हरिश्चन्द्र

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The occasion to provide this information is his response, to the request from the Indian National Science Academy (INSA) at the time of the award of the Srinivasa Ramanujan Medal 1974, for engraving his name in Devanagari letters on the medal.

In that sense, the ways he wrote his name in the two scripts—Roman and Sanskrit—at different stages of his life, with the hyphenated version in Roman script that he adapted from some point on as elaborated elsewhere, do sit consistent with the prevailing linguistic practices.

[4]The reference here means that the source for this is a verse number 375 in third section of the third kāṇḍa of *Amarakosha*, the oldest available Sanskrit lexicon composed in memorizable verse form by the poet Amarasiṃha, who flourished in the 6th century CE.

[5]See Monier-Williams, (1872), *A Sanskrit–English Dictionary*, Clarendon. p. 315.

Article

The Divine in the Minuscule

by Prajnaparamita Barman

To most, proteins are microscopic machines. But I believe they are music frozen in form, poetry spun from atoms; hidden deep within their spirals and folds is a harmony, a geometry of healing, that can reverse diseases, mend broken DNAs, and even regenerate[1] worlds!

Proteins are polymers—like necklaces—made from only 20 different amino acids that fold into intricate three-dimensional shapes—loops, helices, and sheets—guided by chemical interactions. The term *protein* has become so common in our daily language that its profound biological significance and elegance have been somewhat dulled or even forgotten. We associate protein with consumption (fuel for muscles or diets) rather than with the molecular miracles that build, maintain, and animate life. The fact that they literally do everything in a living cell—from translating DNA, building tissues, killing pathogens, to fueling thoughts—yet we flatten that miracle to: "How many grams of protein are in this bar?"

It's like calling a symphony just a *sound*, or a painting just a *pigment*. Over time, the poetry has been replaced with practicality. By overusing the term without depth, we're forgetting the viability of the living code—proteins that don't just exist but are alive with design, folding with purpose, moving with grace, and adapting with quiet intelligence. Every heartbeat, every thought, is powered by the invisible ballet of proteins. In fact, they are the most legendary creations of DNA, which contains the sacred blueprints of every living thing. Imagine looking at proteins through a better lens, so that every time someone uses the word, instead of picturing protein powder or protein bars, they imagine the whirling gears of ATP synthase[2], the symmetric elegance of the viral capsid, and the sparkle of fluorescent proteins lighting up cells in real time. Kind of hits different, doesn't it?

Proteins are not mere molecules; they aren't just pretty—they do things. Each is a tiny machine precisely suited to its task, performing the secret choreography of life, i.e., protein folding.

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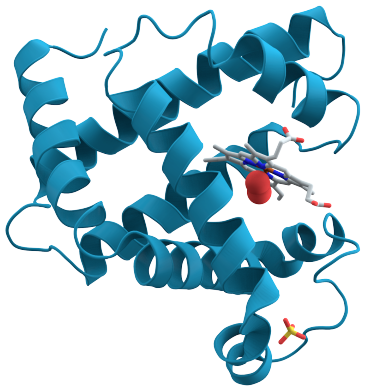
[1]The phrase is artistic license, referring to the potential of protein-engineered systems to reshape and support life. Hence, it is a common speculation.

[2]Adenosine triphosphate (ATP) is the source of energy for use and storage at the cellular level. ATP synthase is a rotary molecular machine responsible for the generation of ATP.



A 3D model of the protein myoglobin is shown, with the α-helices depicted in turquoise. Wikipedia Public Domain.

Think of a long, flexible ribbon made of tiny beads, and each bead is a different kind of amino acid. When first made, this ribbon is linear, like a string of letters before it becomes a poem, and then, without any guidance from hands or eyes, it begins to fold. Not randomly, not by accident, but with an elegance that borders on magic. The act of protein folding is one of nature's quietest miracles. The ribbon twists and curls. Some parts spiral into α-helices, coiled like delicate springs. Others flatten into beta sheets, zig-zagging like pleated silk. Loops connect them—some tight and purposeful, others graceful and long. All of it happens in milliseconds, and always in exactly the right way. No outside force sculpts it; no craftsman molds it.[3] The shape is hidden in the sequence, like destiny waiting to unfold.

The importance of protein folding cannot be overstated. It forms the bridge between genetic code and biological function. Without proper folding, the *biological artisans* cannot do their jobs, and without them doing their jobs, life as we know it would simply cease to exist. Once folded correctly, they become functional: a tool, a machine, or a messenger that carries out a task in the cell. If they fold incorrectly, they cannot bind to the molecules they need to interact with—or worse—they might bind to the wrong ones.

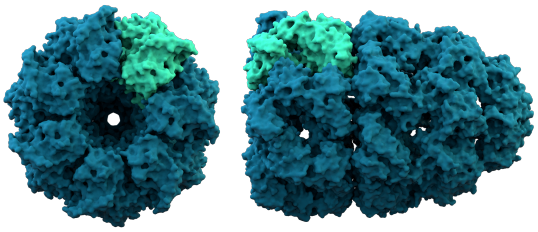
The intricate dance of protein folding echoes the geometry of our own becoming and sketches the story of what it means to be a human. This phenomenon holds a mirror to our own nature. The protein folds because it must—because its function depends on its shape. We too, *fold* as we grow. We adapt, bend, learn, protect, open, and, more so, evolve. Our personality and identity are the result of countless invisible forces. A correctly folded protein is in harmony with its environment—efficient, graceful, balanced. A person too becomes whole when they align with purpose, community, and self.

But during the course of growth, we all make mistakes, get distracted from our goals. We misfold, too. We carry emotional scars, we struggle with identity and direction, we isolate, withdraw, or cause harm—unintentionally.

Similarly, sometimes, proteins misfold. They form clumps, they cause harm, they lose their function. To prevent this, nature has created silent guides, known as *chaperone proteins*. In cells, these molecular therapists gently assist folding—patient and persistent. In life, our chaperones are friends, mentors, therapists, kind strangers, even books or moments of clarity.

[3] This concept is supported in the scientific literature. See Anfinsen's Dogma

We aren't meant to fold alone.



Crystal structure of the chaperonin, a large protein complex involved in protein folding. BY THOMAS SPLETTSTOESSER, WIKIPEDIA COMMONS.

The dynamic folding of the *thread of life* is analogous to emotional growth. Proteins are not static. They shift, refold, breathe. So do we. We grow after heartbreak, we heal, we rewire, we forgive, we become someone new—again and again. A protein changes shape to interact, to adapt, to survive. So do we in love, in grief, in celebration, and in silence. Folding is not failure. Folding is life. Folding is sacred precision. We are not accidents. We are crafted, moment by moment, into something precise and necessary, because every curl and twist of a protein matters. Every experience folds into us; every interaction shapes our emotional structure; every memory adds dimension to who we are. There is no wasted fold in a functional protein, and there is no wasted emotion in a whole human being.

In the end, to fold is to become, to misfold is to hurt, and to refold is to heal. To be a protein is to serve a function, whereas to be a human is to seek meaning. And in both, beauty lies not in simplicity, but in the complexity mastered.

Sometimes the folded ones fall in love—they bind tightly and never let go. Other times, it's a speed date—they touch briefly, forge connections, and part ways. And then there are protein complexes—groups of proteins who decide, "Hey! We work better as a team"; like a band, a startup, or the Avengers. Just like in human society, where we interact to form relationships that shape our identities and roles, proteins, too, interact to trigger countless reactions in the cell. The cellular machinery depends on the interplay of protein–protein interactions—driving molecular intimacy, silent cooperation, and the exquisite dance that underlines all of life.

This is a tale rarely told outside of textbooks, yet it's happening within you—right now, in every heartbeat, every breath, and every thought.

When two living chains interact, they do so by surface shape compatibility, electrostatic charge balance, hydrophobic or hydrophilic forces, hydrogen bonds, and van der Waals attractions.[4] It's not just chemistry. It's recognition. In the language of proteins, touch is function and connection is purpose. One whispering helix touching another can spark a cascade of life-giving reactions. The same is true in life. A kind word, a shared idea, a moment of presence can activate whole paths in someone's journey, because we are not linear beings—we are catalytic.

[4]These are the fundamental forces that govern how proteins and other biomolecules recognize and bind to each other

The connection between proteins leads to a wide array of crucial functions in the body, which dictate life and mold its form. The functionality of the molecular muses is a form of art—an ever-evolving, living masterpiece that defines life, sustains balance, and whispers the codes of longevity. Explaining every function of protein would be a never-ending task, but we can make it more digestible by grouping their functions into broad categories, like a greatest hits list[5]:

> From zygote spark to newborn cry,
> proteins lift us towards the sky.
> They build with tender care,
> they stitch the frame, the bone, the skin,
> and the body's domain.
>
> They signal like a guiding light—
> through pathways lit by day and night.
> They sense the fall before we break,
> heal our wounds, and quietly keep disease at bay.
> They turn the food to strength and fire,
> fueling dreams and the heart's desire.
>
> They regulate the cell's own fate,
> timing precisely when to grow and wait.
> Hemoglobin holds the breath,
> transports ions and oxygen—
> carrying life and warding death.
>
> They write the scripts, play the roles,
> and tear down the set when the story halts.
> In aging, their gradual misfolding becomes a fading brushstroke,
> until death stills the hand...
> But even then, the pattern lives on—
> copied, passed, and reborn.
>
> They are the artists within us—
> revitalizing DNA's quiet script
> by cradling life from matter forlorn.

When you catch your reflection next time, will you pause—just for a moment—to truly behold what you are? Because behind that glint in your eye, and the pulse at your wrist, a thousand proteins are still composing you. Even as you stand still, actin and myosin are at

[5]Also see *My Proteins* by *Jane Hirshfield* which inspired the author's poem here.

work, keeping you upright and poised. Collagen holds the architecture of your skin together, while elastin gently yields and springs back with every smile. Crystallins in your eyes remain perfectly folded, bending light so you can gaze at the world—and into yourself.

In your brain, receptor proteins open and close like gates to let through whispers of thoughts, memories, and emotions. Dopamine, serotonin, oxytocin—each a messenger crafted by enzymes—comprise the words of your inner dialogue, shaped entirely by proteins. Your immune system is a legion of proteins like antibodies, precisely shaped, scanning for signs of trouble, remembering every enemy they've ever met, so you don't have to! And when one protein finishes its task, it is broken down—not discarded, but recycled. Its amino acids find new purpose, a new form. It becomes part of the next story. So you see, this story of you? It doesn't really end! It loops, regenerates, and evolves.

From the first fold of a protein to the last sigh of a cell, you are not just skin and bones but a biological poem in motion—composed by DNA, written by evolution, and echoed through every movement, your body is a symphony of life itself.

And as the cadence returns to the root, looping through memory and matter, *what part of the melody will you leave behind?*

Article

A Goodbye

by Utkarsh Kashyap

This morning, the garden was very quiet, with only the cold breeze rustling a few leaves now and then. The sound of the rustling of foliage seemed to be the sound of silence yet to be touched and assimilated. Today, the garden was empty—not just of people, but of presence. I can't remember the last time it looked so deserted. No one cleared the dry leaves from the benches or pushed the swings. I don't know how to count, but the trees also seemed to have as many berries as yesterday. Only the chilly wind touched them and dropped some berries down, but it didn't change the appearance much.

Sometimes when I look at these pigeons, I wonder how happy they are with each other. They're never alone—sitting together on branches, eating grains side by side, and chatting with the breeze. In a flash, they fly far away, but always together. And here I am, wandering alone—a *stray* as the 'mature people' used to call me or an *innocent*, as the 'immature ones' who come here often, call me. I wonder if I even have a name. They call me with strange, different sounds. Sometimes, they shout suddenly to scare me, maybe because it's fun for them. But I get frightened, and a scared yelp slips out of my heart. Often, they toss me food they don't want. Other times, I just look at them with hopeful eyes, waiting. I keep hoping until the last bite, but well… *My world is just the corners of this garden*.

Most of the time, people don't notice me or bother me. They are immersed in their own activities of both monotony and joy, which is why they come to the garden. But Mr. Ray, an old and kind man, is altogether different. He used to come here just to read his books quietly. He is the one who often gave me bits of food. He loves to travel, and I overheard him talking on the phone with some people that in a few days, he's leaving for Kolkata for a few months, where his family lives. Though that's his birthplace, he regrets knowing so little about it, and this trip will help him learn more.

But today, it's completely silent. Not a single person has shown up, even though the sun is high overhead. Whew! Let's see if there is any water to drink.

Did I just hear someone laugh? I listened carefully—no, there's no sound. Wait, somewhere nearby, a few people are laughing. I can hear them. That laughter sounds eerie, almost

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frightening. Along with that eerie laughter, I could now hear loud, stomping footsteps. As the terrifying laughter and earth-shaking steps grew louder, I felt more and more scared. It was clear this was a group. I quickly slipped into the hole I'd dug behind the bushes and hid, waiting for them to come closer. There were few people. Their clothes were badly covered with dust, and they stumbled as if they might fall any moment, yet every time they managed to save themselves. They held glass bottles in their hands, their eyes half-closed as if eager to sleep, their hair messy, and their faces smeared with grime. But their teeth—they could clearly be seen through their frightening laughter.

As they approached, the air was filled with an intense and strange stench —it was the sharp smell of alcohol, and these men were drunkards. All of them sat in a circle on the grass, placing the bottle of liquor in the middle. They started picking it up, drinking, laughing, and talking loudly.

One of them spoke, "Wanna know who's a real pal? Gambling shows ya, plain as day. Them guys who said they were my best buds—they showed what they're really like, today. Got no cash in your pocket, then why the heck you showin' up to gamble, huh?"

Another one said, "But we're not deceitful pigs like them, my friend. That's why we're here, sticking by you through all this."

"Yeah!" the first one shouted.

"Not... not you, my friends—those... those leechers of the gutter! Those who lose at cards and run off, tossing the deck!"

"Forget them, friend!" the third one chimed in.

"Taste this nectar and curse them out till your heart feels lighter."

"Ha, ha!"

They all burst into loud laughter.

They pulled out glasses from their pockets, quickly wiped them against their shirt sleeves, and started pouring drinks, clinking their glasses together and shouting, "Cheers!"

"The garden was better off deserted than disturbed by these people," I thought.

"Buddy, can you help me with something small? A piece of food has been stuck in my teeth since morning, and it's driving me crazy. Grab a thin twig from that bush over there so I can remove it."

"Absolutely, friend, I'll get it!" the other replied.

He is coming right towards me. What do I do now? Where do I go? They'll see me!
But they should not hurt me for no reason, right? But, they're all drunk.

The man was now standing right by the bushes, directly in front of me, but it seemed he didn't notice me. He was looking for a thin stick.

"Yes! Found one. This'll do the job," he said. "It'll get all the bits out."

Phew, he didn't see me. I was worrying for nothing.

But then he shouted, "Hey, friend, come quick! I think there's someone behind the bushes. I'll check."

How did he know? But why should I worry? Maybe… They'll give me some food!

"Look, friends! It's been hiding here, listening to everything we said!"

"What? I think it too, wants some nectar, huh? Come here, buddy — let me give you a taste."

As soon as I sensed danger, I started barking at them, "Go away!" I barked, but… they didn't listen — or rather, 'they just heard'.

I had to run, so I did, with all of them chasing after me. But where could I go? In the end, a wall blocked my path, and I had to stop. All of them stood in front of me.

"You ran a lot, little one," they said. "Where are you going to run now?"

One of them grabbed me by my tail and dangled me upside down. It hurt so much. My back was in agony, and I didn't even have the strength to scream. I tried with all my might, but my voice choked. Pain and panic made my heart race. My throat was dry, and I could barely breathe.

Just then, a loud voice came from the garden's entrance:

"Hey, loser! Have you opened a circus or what? Listen, If you've got the guts, come to the big banyan tree. Bhaiya's ready to beat you. It took a lot to convince him—nobody wants to play with a cheat like you!"

Hearing this, the man loosened his grip on my tail, and I crashed to the ground. The moment I was free, I bolted toward the bushes desperately, crouching low. I don't know where that sudden burst of energy came from.

Hearing that challenge, the man got angry and smashed the bottle of nectar he was holding. The pieces of the glass bottle scattered everywhere, though I can barely see them. Then they grabbed their belongings and left.

My legs were too weak to carry my own weight after the fall. I limped along, stumbling—falling face first a few times, sometimes flipping over, sometimes forgetting my injured leg and trying to use all of them and each time, a muffled, pain filled yelp escaped me. I licked the wounds on

my legs, belly, and tail to ease the pain a bit, then crawled into my hole and fell asleep. That's all I could do.

"Aaaaah!"

A loud scream startled me awake, making my heart race again. Can't these people just keep quiet for a while? Why does everyone have to bother me? A piece of glass had pierced a boy's foot, but the wound wasn't too deep. Anyway, why do I care? I know they all come to trouble me. I licked my tail and belly again and went back to sleep.

There was a boy sitting on a bench, sobbing quietly. He wasn't crying out loud, but tears streamed down his face, and he didn't blink. Hesitant and limping, I slowly crept out from the bushes. He glanced at me, then turned his face away, not showing any real change in his expression.

At first, I thought about going towards him, but I didn't want to risk getting in trouble for myself. So I limped past him towards the neem tree where my bowl was, hoping to drink some water. But my limping seemed to draw his attention. Dodging the scattered pieces of glass, I reached there and as I looked into the bowl—it was empty.

A moment later, water started pouring in, filling it up. I looked up and saw it was the same boy, pouring water from his bottle into my bowl. Now a slight smile on his face showed kindness. For a while, he watched me, then checked to see if the bowl was full. Once it was, he went back to the bench and sat down.

I started drinking the water. After quenching my thirst, I turned back toward the bushes. As I limped past him again, he was carefully collecting the glass pieces and piling them on the bench so they wouldn't pierce the feet of anyone walking by.

While passing through him, he asked softly, almost sadly, "Do you want some food?"

I hesitated, unsure how to respond. Then he pulled out some cookies from a packet and showed them to me. I slowly moved towards him. Seeing my reaction, he said, "I knew you wouldn't understand my words, but you sure understand these cookies."

With that, he placed them on the ground, and I started eating.

"It's so peaceful here," he added.

I listened to him while eating, but his words didn't mean much to me. My body was still tired and sore, and all I wanted was to rest in my hole. I quickly finished the food and limped towards my spot.

The boy watched me limp with a mix of surprise and pity. When I reached the bushes, I saw him scratching shapes onto a nearby tree trunk with something sharp, completely absorbed. After glancing at his drawings for a bit, I curled up in my hole and fell asleep.

A while later, soft, pained sobs woke me up, making my ears perk. What now? I thought, annoyed, opening my sleepy eyes. The boy was quietly whimpering again. What's his problem? Why is he still here when everyone else is at home? Why hasn't he left?

I stepped out of the bushes. When he saw me, he went silent. After a moment, he held out some cookies to lure me closer. Honestly, he could've called me without that bribe. I felt no danger, so I went to him. I ate the cookies and sat on the ground near the bench.

"How did you hurt your leg?" he asked. "Oh, I forgot—you don't understand human words."

That wasn't true. I do understand humans, as long as one is around, like this boy.

He looked at me for a bit, then went back to carving some shapes on the tree trunk. Humans have strange hobbies—they find 'art'—as they called it—anywhere they want. This boy might become an artist someday. My leg felt a little better, but the tail still hurt.

"Let's play a game!" he said excitedly. "It's called fetch. I've seen it in movies. The rules are simple."

He picked up a thin stick and said, "I'll throw it a little way, and you run to bring it back, okay? In return, I'll give you a cookie."

I understood the rules, but I sure wasn't going to run for it.

He threw the stick a short distance and looked at me with hopeful eyes. But I, confused and unsure, just sat there. Thinking I didn't understand, he made strange gestures to explain, waving cookies to tempt me. How could I tell him the problem was something else?

After several tries, he shouted, cried, and gritted his teeth, saying, "Everyone's selfish! No one wants to play with me. I'm the worst!" He started cursing himself, tears streaming down. When that wasn't enough, he started slapping himself incessantly, sobbing and calling himself names.

I couldn't stay still anymore. I couldn't run, but I limped over, gently picked up the stick in my mouth, and placed it on the bench in front of him. His crying softened a bit, and as promised, he gave me a cookie.

"I'm sorry," he said. "I know you don't understand my words, but maybe you feel my sadness. I'm not mad at you. I've had some experiences that have shaped me in this way. Even though you won't understand, I want to share some things. My mom says it makes the heart lighter."

He then began speaking…

"I used to have lots of friends. Every evening, we'd come to this garden to play. One day, I suddenly got a sharp pain in my stomach, and it started swelling. It happened often. When I stayed hungry, I felt fine, but if I ate a full meal, I'd vomit, and the pain and swelling would

start again. The doctor said I had a bowel obstruction. The part connecting my small and large intestines was getting narrower, making it hard for food to pass. Because of this, I couldn't digest solid food and had to rely on liquids. I became weak and frail. For six months, I took medicines and followed a strict diet. That's why I stopped playing or meeting friends. Every day, I ate tasteless porridge, watery lentils, and other bland things. I couldn't eat what I wanted and had to stay home. No festivals or celebrations happened at our house and everyone just prayed for my health.

Slowly, those painful days passed, and I started getting better. I began eating solid food little by little, and I felt stronger and more energetic. My face started to glow again and I was gaining weight. Everything was improving, and my mother had promised me that today she would cook and feed me my favorite dish. I was happily eating and went to the balcony. But what I saw brought back clouds of sadness. In those six months, so much had changed. My friends had made new friends whom I didn't know. They all went out to play cricket often—oh, how happy they always were! They looked like they didn't need anything—or anyone, not even me… One of them glanced at me but then turned away. Why? Will they never fall prey to any disease in the future or haven't suffered from the same in the past? Feeling hurt, I came here and found you. Maybe you're alone too, with no friends. I have a proposition—Why don't we become each other's friends?"

I couldn't believe someone wanted me as a friend. And suddenly all my pain seemed to vanish. He stood up and carved more shapes on the tree trunk.

"Let's play some more!"

This time, I ran fast, fetching the stick with excitement.

A new energy—friendship—surged through me. We played other games too. Sometimes he'd hide cookies, and I'd find them. Other times, we raced each other. I'd never felt so happy or full of life before. We were both exhausted and sat on the bench, resting and eating cookies.

"My friends left me without saying goodbye," he said, "but I promise I'll never do that to you. We'll always be together. I'll come to play with you every day."

I wagged my tail in agreement. We were so tired that we fell asleep right there on the bench.

A little later, when I woke up, I pictured us running, falling, and laughing together, everything feeling perfect. It was like a dream. But was it? To check, I looked at my friend beside me—but… no one was there.

Was it all a dream? No, the cookie packet was still on the bench, and the stick was there too. I searched the whole garden, every corner, every spot. He was nowhere. He'd promised he'd never leave without saying goodbye. He gave me his word.

New shapes had appeared on the tree trunk, ones that weren't there before I fell asleep. After

the last shape, he'd stuck the sharp object into the trunk. But where did he go? It wasn't even evening yet. Everything except my thoughts had gone still. The joyful atmosphere we'd created together was now completely gone.

Evening was settling in, welcoming the night by scattering stars throughout her path in the sky as the day faded. When my thoughts began to quiet, the peace turned into silence. The winds were turning cold again. After the darkness in my heart, the environment around me was growing dim too. The sharp, chilly gusts scattered the glass pieces he had carefully piled on the bench, spreading them all around. Dry leaves began to swirl in the wind again.

Will he come back tomorrow? He said he'd come every day, that we'd play together... Has he gone forever? But he didn't say goodbye, so that means he'll return. That certainly means he'll return, and I'll wait for him.

After that day, the boy never returned to the garden. Due to a lack of proper care, poor food, and the harsh, hot weather, the little animal waited and waited, dying within three or four weeks. On that tree trunk, the shapes the boy carved are still there, and the sharp object remains stuck after the final shape. Until now, no one had noticed those carvings. After a long trip to Kolkata, Mr. Ray returned to his residence and came to this garden. Today, he coincidentally sat on the same bench where that incident happened months ago. As he settled to rest, his eyes fell on the shapes carved on the nearby trunk. To a conscious mind, they were no longer just shapes—they had become words. Mr. Ray began to read them—

Who is a friend?
Thou art — I know.
Who is the love?
Thou art — I know.
But...
Doth it endure,
Till the dark eves do grow?
And then...
We shall meet upon the canvas,
"But I am painted blank," it always sighed.
GoodBye, my friend—
Thy death hath died.

Resources Palette

Suggested Readings by Readers

- **Siddhartha** by **Herman Hesse**
  In *Siddhartha*, *Herman Hesse* offers a gentle companionship– one that slowly leads towards something that cannot be named. The book revolves around the story of a man who breaks away from the bounds of traditionally structured wisdom, in search of peace- one that must fill his soul. He then finds himself emerging from a religiously inclined family into a life, not devoid of materialism, and finally leading up to a gentle question that stirs something within you. The journey isn't linear, it's spiral, more so recursive. Siddhartha, doesn't offer you answers but perhaps a quiet contemplation- something that will sit with you, long after the book is gone.

- **The Metamorphosis** by **Franz Kafka**
  In *The Metamorphosis, Kafka* touches on a man's encounter with sudden and unexpected meaninglessness. This novella strips one off the comfort of understanding, offering instead a stark portrayal of alienation, the collapse of identity, and the quiet violence of being unneeded. On a seemingly simple and normal day, the protagonist wakes up to find himself being transformed into an insect. The story then revolves around the subsequent erasure of one's identity and forces one to focus on the fragility of the self. It sneaks up, slowly asking- what remains of a person when all external affirmations—work, recognition, speech—are lost?

- **The Little Prince** by **Antoine de Saint-Exupéry**
  The Little Prince by *Antoine de Saint-Exupéry* is a beautifully penned fable which questions the necessities of life and how one, in the process of growing up and in taking care of 'matters of consequences', forgets to be oneself. It offers a deep philosophical meditation on love, loss, perception, and the quiet tragedy of growing up. And quietly conveys that to see clearly, one might sometimes need to unlearn.

- **A Man Called Ove** by **Fredrik Backman**
  In this novel, *Backman* offers a second-person experience of the slow and reluctant opening of the human heart- of how grief and sorrow are many times covered in anger. The novel revolves around an old, grumpy man named Ove who refuses to let anybody into his life, despite the grief and pain. The people around him however, do not offer him a grand, symbolic gesture and sense of belonging-ness, they simply arrive and stay. The novel quietly touches on the edges of meaning and belonging and affirms that healing and revelation often come not through ideas, but through presence, constancy, and the strange grace of being seen exactly as we are.

- **The Curious Incident of the Dog in the Night-time** by **Mark Haddon**

This novel by *Mark Haddon* offers a view into the life of a 15 year old boy, amidst some unusual circumstances. The boy inclines towards thinking logically, structurally and with mathematical clarity. The novel lets one see through a lens, not so common– one that is unusual however, more gentle and tender in its view. The book describes raw emotions without the human-ly need to over-explain. The book offers a beautiful and moving reminder that there are many ways to map the world, and that even the most rigid forms of logic can lead us to something deeply human.

- **Letters to a Young Mathematician** by **Ian Stewart**
  Letters to a Young Mathematician by *Stewart* is a quiet, generous companion for anyone standing at the threshold of mathematics—not just as a subject, but as a life. Stewart does not romanticize mathematics—he offers it as a serious, demanding, and deeply rewarding pursuit, one that asks not only for skill but for a certain disposition: patience, curiosity, and the ability to sit with abstraction long enough for beauty to reveal itself, and it's demand of humility, attention, and the courage to keep asking.

- **A Mathematician's Apology** by **G.H. Hardy**
  Hardy wrote this book when he felt his creative powers fading. The book carries the quiet ache of someone looking back, trying to make sense of a life devoted to abstraction. Hardy does not argue for the utility of mathematics—he dismisses that entirely. Instead, he insists on its aesthetic value, placing it alongside poetry and art, claiming that a good theorem, like a good poem, must be beautiful. What emerges is a portrait of mathematics as a deeply human activity—not despite its detachment from the world, but because of it. In its refusal to justify itself through usefulness, Hardy's mathematics becomes something closer to a spiritual practice. The book illuminates a path rarely seen—one where meaning lies not in what we do for the world, but in the act of doing something well, simply because it is beautiful.

Web Resources

- Perimeter Institute Recorded Seminar Archive on Mathematics and Physics
  https://pirsa.org/
- The Grothendieck Circle
  https://www.grothendieckcircle.org/
- All I really need to know... by David P. Stern
  https://physicstoday.scitation.org/doi/10.1063/1.2808904
- A Physics Booklist maintained by John Baez
  https://math.ucr.edu/home/baez/physics/Administrivia/booklist.html

- Collected Lectures and Talks in Biology
  https://www.ibiology.org/
- Archive for The Whole Earth Publications
  https://wholeearth.info/
- Music Archive by Rajan Parrikar
  https://www.parrikar.org/
- Spic Macay Archive
  https://www.spicmacay.org/
- Youtube Archive maintained by Carsten Wicke on Rudraveena and recordings
  https://www.youtube.com/@RudraVeena
- The Bridges Archive
  https://archive.bridgesmathart.org/

Upcoming Conferences and Programs

- Upcoming conferences in algebraic geometry maintained by Ravi Vakil
  https://virtualmath1.stanford.edu/ vakil/conferences.html
- **ST4** (July 14, 2025 - July 26, 2025) at IISER, Bhopal;.
  Talks given by students intended for students in the area of theoretical physics.
  https://st4physics.wixsite.com/2025
- **Les Houches Summer School 2025: Exact Solvability and Quantum Information** (Aug 04, 2025 - Aug 29, 2025) at Les Houches, France.
  https://www.lptms.universite-paris-saclay.fr/leshouches2025/
- **Conference in Memory of Yuri Manin** (Aug 11, 2025 - Aug 15, 2025) at Max Planck Institute for Mathematics, Bonn.
  https://www.mpim-bonn.mpg.de/maninmemorial
- **Geometry and Analysis of Minimal Surfaces** (Aug 18, 2025 - Aug 29, 2025) at ICTS, Bangalore.
  https://www.icts.res.in/program/GAMS
- **Gravity, Geometry, and Operator Algebras** (Sept 01, 2025 - Sept 05, 2025) at SIMIS, China.
  https://www.simis.cn/gravity-geometry-and-operator-algebras/
- **QFT at the crossroads between Mathematics and Physics** (Sept 15, 2025 - Sept 17, 2025) at ICTS, Bangalore.
  https://www.icts.res.in/program/GAMS

- **Millennium Prize Problems Lecture Series** (Sept 17 2025 - Apr 15 2026) at Harvard Science Center, Harvard University.
  https://cmsa.fas.harvard.edu/millennium/
- **Operator Algebras and Mathematical Physics** (Sep 20 2025 - Oct 03 2025) at ICMS, Edinburgh.
  https://icms.ac.uk/activities/workshop/oamp/
- **100 Years of Quantum: Perspectives on its Past, Present, and Future** (Oct 20, 2025, Oct 24, 2025) at Perimeter Institute for Theoretical Physics.
  https://events.perimeterinstitute.ca/event/1013/
- **New Structures and Techniques in p-adic Geometry** (Oct 27, 2025 - Oct 31, 2025) at IHES, France.
  https://indico.math.cnrs.fr/event/14073/
- **Holomorphic-topological field theories and representation theory** (Nov 03, 2025 - Nov 07, 2025) at Perimeter Institute for Theoretical Physics.
  https://events.perimeterinstitute.ca/event/1013/
- **Millennium Prize Problems Lecture Series** (Sept 17 2025 - Apr 15 2026) at Harvard Science Center, Harvard University.
  https://cmsa.fas.harvard.edu/millennium/

so many eyes,
as many truths…