# Scientist & mentor

**Deeply immersed in acquiring and creating knowledge, Roddam Narasimha enjoyed the bliss of pursuing research with meticulous attention to detail, and could masterfully communicate that enjoyment to inspire young minds.** BY **K.R. SREENIVASAN**

BY now, the news that Professor Roddam Narasimha (RN) passed away on December 14, at the age of 87, has spread in the nation at large. He was active until nearly the end; he is survived by wife, Dr Neelima Narasimha, and daughter, Dr Maithreyi Narasimha.

Several obituaries of RN have already appeared in diverse news outlets, small and large, and one of them has just been written by me and Professor G.S. Bhat of the Indian Institute of Science, another student of RN, for *Current Science*. Even earlier, Bhat and I had the good fortune of writing a longish article, containing a perspective of RN's life-time work, also in *Current Science*, under the larger heading of "Living legends in Indian science". Our good fortune was that RN read our account of his legacy, and we have reasons to believe that it pleased him. I had earlier written an assessment of RN's scientific work for his 70th birthday meeting, and, ten years earlier, authored a similar preface for a book edited with S.M. Deshpande, A. Prabhu and P.R. Viswanath, all of whom are RN's students, following a celebratory meeting on RN's 60th birthday.

RN was an important part of my intellectual life for more than 50 years. I am still distraught and cannot bring myself to write a clear-headed account of him; and I have not yet had the time to study his writings carefully. So I will make superficial comments about his science and personal qualities, and briefly present two additional aspects. The first is on how his personal journey as a scientist began. RN wrote about that experience, which I will share with the hope that it will inspire some young people. One shouldn't think that identical circumstances prevail today or are relevant in specific detail, so the essential takeaway is the spirit. I will next discuss RN's theory of Indic knowledge; he neither took the view that everything worth knowing was known to the ancients, nor that everything from the past is worthless. This aspect of his scholarly work, to which I can only provide a sign post, is important for the young people of India today, who should shape their opinions on the basis of serious study.

Given the perfunctory nature of this article, I should warn the reader that she has to read the articles cited above for getting a fuller picture of RN. Two autobiographical narratives published as interviews in *Bhavana* will more or less complete the picture. One of these days, it is clear that a more insightful and comprehensive essay should be written about RN.

## WHAT MOTIVATED RN TO BECOME A SCIENTIST?

In 2003 I was appointed the Director of the International Center for Theoretical Physics in Trieste (ICTP), Italy. Soon after that, I edited a book called *One Hundred Reasons to be a Scientist*. This was a collection of nearly 100 articles, two or four pages in length, written by eminent scientists on what got them interested in science as young students. Many of the writers were Nobel Laureates and Fields Medalists. They generously shared accounts of the influences of their youth; some of them spoke about parents, teachers, accidental encounters, etc., but it was clear that an external influence and opportunity of some kind was most often a principal motivator. I commissioned the book because I felt that it would inspire young people from all over the world. The book has been translated into several languages around the world and I gave away thousands of copies to many scientists from developing countries. You should google it and enjoy reading it: http://bose.res.in/~library/FILES/ebooks/100reasons.pdf

RN's early influences were written under the title "How I became a scientist". It begins as follows:

"It actually started at home. My father was among the early graduates in science in the small town he came from, and went on to study with the great Indian physicist Meghanad Saha, who was then teaching at Allahabad (more than a thousand km from home). Returning with a Master's degree, father taught at Central College in Bangalore, and, in his later years, wrote extensively about science in Kannada, the language of this part of India. He taught me very little physics or science directly, but his example and attitude—scientifically modern, socially liberal and culturally conservative—taught me something more basic, namely pride. My mother did not go to school beyond age ten, but she was an extremely well read and cultivated person—also proud. In the prayers she taught us to recite before going to bed the only things that we asked from God were intelligence and knowledge.

BY SPECIAL ARRANGEMENT

**RODDAM NARASIMHA.** Almost until the end of his life, he was busy with his science, even co-authoring a paper in 2020 on the transmission of COVID-19.

"At school I was fortunate to have some great teachers. One of them managed to get the late C.V. Raman, Nobel Laureate, to visit us. Raman was then the biggest name in Indian science, and he spoke with such wit and verve about his work that he had the audience in the palm of his hand—both kids and teachers. Mr. KVR, the teacher who arranged the Raman visit, also taught me to value writing—briefly and honestly. In those numerous examinations we used to have, there were often questions of the kind 'How many planets are there in the solar system?' I would just answer: 9, and would be severely rebuked by my other teachers for not *naming* the planets as well. This I thought was unfair, for the question had not asked for the *names*. Mr. KVR stood by me on such occasions, and so grew a bond between us—never personally close, but full of affection on one side and regard on the other. But another teacher became personally close, and often took me and a few other students out—for coffee, snacks and long chats. He once casually presented two books to me. One was the *Lives of Great Scientists*, and it opened my eyes to the strange intellectual world of (western) science that I immediately found fascinating. The other book was a Kannada trans-creation of Lewis Carroll's *Alice in Wonderland*, which I fell in love with. How did Mr. BLA know so unerringly what books would make an extraordinary impression on me?

"By the time I was to enter university in 1949, physics was one thing that I was seriously thinking of doing, but the vast (bloodless) political and social revolution that was then sweeping south India made this impossible. I eventually went to the Government Engineering College at Bangalore to study mechanical engineering. But the most inspiring event of those years was a visit I made to the Indian Institute of Science (IISc) when they had an Open Day. In the quadrangle of the Department of Aeronautical Engineering (which had just recently been started) stood a lovely, World War II Spitfire, loaned for the occasion by the Indian Air Force. That was my first close encounter with an aircraft, and it opened another world for me. What struck me at that time was how smooth and graceful the exterior of the Spitfire looked (in particular its beautiful elliptic wings), but how complicated it was if I looked at the insides—which seemed like a jungle of cables, pipes, ducts, valves and so on. It seemed astonishing to me that beneath those graceful curves and surfaces (which I took to come from mathematics) lay hidden a bewilderingly complex technology—and I marvelled at those extraordinary people who had apparently mastered both.

"So when I got my bachelor's degree I wanted to do aeronautics, but this was very unfashionable at the time. At my father's suggestion I consulted a family friend at the Institute [of Science]. He brusquely told me not to be a fool: the right thing to do was to join the Indian Railway Service or Burmah Shell (the equivalents those days of a fat software job in today's Bangalore). I went back dejected to my father with our friend's advice, but he only asked me very simply, 'So what do you want to do?' I said I was bent on aeronautics. He just said, 'Go ahead, then.' So a matter that I had thought might have to be discussed over hours was settled in two minutes, and I ended up at the Indian Institute of Science—where I have stayed in some capacity or the other for most of the last fifty years."

My main point here is that parents (or influential relatives), teachers and some exciting encounters (C.V. Raman and Spitfire in this instance) drive the interest of many young students towards science (interpreted broadly). This appears to be true in the lives of all those who became scientists or serious intellectuals. Science is no doubt important for the economy, defence, improved standard of living, etc., but the greatest reason for doing science is that it provides a perspective on our place in the universe as human beings—indeed on what it is to be human. It helps us overcome our otherwise preconceived notions and provides a key to basic workings of nature. But it should not be forgotten

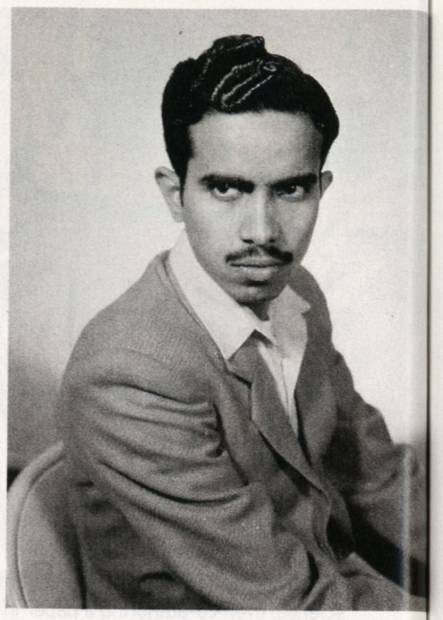
that, even as science constantly attempts to arrive at improved models of reality, its universality drives us to great wonderment: how can one not wonder about the fact that the cosmic microwave radiation, which we can measure even today, is the relic of Big Bang after the baryonic matter separated, or that the laws of nature are universal in the heavens and on the earth? To marvel sometimes about such deep mysteries, even as we make progress a tiny bit at a time, makes us better individuals by endowing humility, grace and tolerance for other people's foibles. We should keep all this in mind as we encourage a youngster in our families or circles of friends towards taking up science.

## BRIEF ACCOUNT OF RN'S SCIENTIFIC WORK

As he had desired, in 1953, RN indeed joined the Department of Aeronautical Engineering at IISc for a Diploma, working with the famed Satish Dhawan for the Associates thesis. His two papers on laminar/turbulent transition, one of them with Dhawan, are still among the most influential fluid dynamics papers to have come from Bangalore. On Dhawan's advice, RN went to Caltech in Pasadena, in 1957, for his PhD thesis. For his doctoral thesis, RN started working on aeroacoustics and also on the theory of the Boltzmann equation with the Bhatnagar-Gross-Krook (BGK) approximation developed a few years earlier. This work drew immediate attention: Russia had just launched the first space vehicle Sputnik and launching a satellite became a national objective in the United States; rarefied gas dynamics provides an approximation of flow around space vehicles, so RN's expertise assumed sufficient importance and he was hired as a consultant, while still a student, by one of several companies supporting NASA's (National Aeronautics and Space Administration) space programme. RN completed his PhD in 1961 (thesis title: "Some flow problems in rarefied gas dynamics"). The stay at Caltech was extremely satisfying, and the association with Hans Liepmann, in particular, was very rewarding: this influence was felt even more by virtue of wide-ranging topics that were discussed informally between them over the years.

RN's performance and skill sets generated employment opportunities for him in the U.S., but he was keen on returning to Bangalore – which he did towards the end of 1962. Perhaps inspired by what he saw at Caltech, he attempted a balance between building a broad-based fluid dynamics group and doing research himself. In a few years' time there was a group of outstanding students and assistants who quickly became experts in their subjects. Much of the research those days concerned shock structure and the Boltzmann equation, turbulent bursting, supersonic flows, flow control, wake structure and turbulence modelling, reverse transition or relaminarisation (where a turbulent flow goes back to an orderly laminar state) and drag reduction. An ingenious example of how the boundary layer theory could be applied outside of fluid mechanics is his work on the vibration of elastic strings.

In the mid 1970s, an interdisciplinary group interested in the monsoons started nucleating at IISc and eventually led to the setting up of the Centre for Atmospheric (and now also Oceanic) Sciences (CAS) in 1982 with RN as its convenor. He became convinced that an important fluid-dynamical problem to tackle was the monsoons, and central to this effort were convective clouds. While there was a plethora of past studies on cloud microphysics (dealing with how cloud droplets form and grow), cloud dynamics remained poorly understood, particularly the consequences of the release of latent heat on entrainment and mixing processes. So, laboratory simulation of clouds was attempted at CAS and RN's group found a novel way to set up cloud-like plumes in the laboratory. He conceived the idea of a monsoon field programme to measure the atmospheric boundary layer properties and develop flux relations relevant to monsoon conditions, and



BY SPECIAL ARRANGEMENT

**AS A** student.

MONTBLEX (Monsoon Trough Boundary Layer Experiment) was carried out in the Indo-Gangetic Plains. The data analysis led to new formulation for surface flux at low winds.

Almost until the end of his life, he was busy with his science; it is astonishing, even for RN, that he co-authored some eight papers in 2020, on topics ranging from clouds to jets, from flow over turbine blades to the statistical mechanics of vortices, including one on the transmission of COVID-19. More of his papers, on both science and philosophy, will no doubt be published posthumously.

RN was greatly admired for his far-reaching science. His students and collaborators were completely aware that he was a high-level researcher. Especially the earlier generation of his students, who knew him when he pursued science with single-minded love and no other engagements, thought that he was destined to remain that way. In fact, they were certain that his temperament was not suited for becoming a great administrator. Time has proven them wrong. He has shouldered great responsibilities with a poise and effectiveness that can only come from an inner strength and confidence built up during his young and formative days. Aside from his service as the department chairman and dean at IISc, he was the Director of the National Aerospace Laboratory for some 10 years, the Director of the National Institute for Advanced Studies for some seven, and created the Engineering Mechanics Unit in the Jawaharlal Nehru Centre for Advanced Scientific Research. He was the president of the Indian Academy of Sciences. In every administrative capacity that came his way (for he never sought one) he was never content to manage it effectively but was always engaged in new initiatives and left the place much better than it was at the time he assumed office. He has served the country in many capacities. As a member of the Scientific Advisory Council to former Prime Ministers Rajiv Gandhi and Manmohan Singh, he was instrumental in establishing a major parallel computing initiative in the country and in establishing the Ministry of Earth Sciences. He served a critical role as the longest-serving Member of the Space Commission.

Recognition of his special standing as a researcher and a leader has come from far and wide. Among the prestigious visiting positions he held, reflecting this standing, I list only three: Clark B. Millikan Professor and Sherman Fairchild Distinguished Scholar at Caltech, and the Jawaharlal Nehru Professor of Engineering at Cambridge University. He has been elected Member of the US National Academy of Sciences and of Engineering, Fellow of the Royal Society of London, Fellow of the American Academy of Arts and Science, Fellow of The World Academy of Sciences (TWAS), and Fellow of all the prestigious science academies in India. Some of other distinctions include the Bhatnagar Award, the Gujarmal Modi Award, the Ramanujan Award, the Aryabhata Award, the Padma Vibhushan, the National Science Chair, and many others. He had the rare distinction of being elected Honorary Fellow of the Indian Institute of Science in 2008.

Bhat and I wrote the following in our latest *Current Science* article. I repeat it here without attempting to rephrase it.

"RN was a highly cultured scholar and combined the best from the West and the East. He attempted a balance between 'building' and 'doing' and brought to bear his unique perspective on every problem he touched. His awareness of the complexity of the country only enhanced his keen love for it. He firmly believed that academies should not merely recommend action to the government, but also constructively do things themselves. Deeply immersed in acquiring and creating knowledge, he enjoyed the bliss of pursuing research with meticulous attention to detail, and could masterfully communicate that enjoyment to inspire young minds. Rather than follow fashionable research trends, he taught his students to work on questions that excited them and pursue them in depth, emphasising quality over quantity. He was progressive in his thinking on social issues and seemed free of prejudices connected with region, religion, gender, and age.

"The many honours and recognitions that came RN's way made no difference to his personal qualities that endeared him to so many in the first place: easy accessibility to all—despite disparities of their stations in life (whether a novice student, a distinguished colleague, or a high-level official); the dignity with which he interacted with people of all walks of life; abiding interest in intellectual pursuits and love for truth, scientific tenor and erudition; unprejudiced and disciplined advice that he provided when it was sought; clarity of thought in spoken and written words; the personal example he naturally and effortlessly set, the genuineness of curiosity he displayed, and the inspiration he provided to a number of younger colleagues. He mentored generations of students and supported their scientific activities long after they established their own careers. He was generous with his time and gently encouraged others in their pursuits.

"These qualities made him an extraordinary human being, winning a place in the hearts of many friends all over the world. All his former students and colleagues, and many others who came in contact with him, miss him and perceive the void that his demise has created; they will remember him and his legacy for a long time."

## INDIC SCIENTIFIC TRADITION

Also around 2004, I established at the International Centre for Theoretical Physics (ICTP) an annual prize in the name of the spectacular mathematician, Srinivasa Ramanujan. For the funding, I had to make the case to the Norwegian Academy. My own belief was that Ramanujan, who did not have a formal training, did mathematics in ways that better trained mathematicians could not, or would not, do. I wondered if, going back in history, India had other examples of such immense intuition, even if not always in mathematics.

I knew that RN was interested in such subjects, so I posed the following question to him at one time: Though I had in mind the specific context of S. Ramanujan, I also had the likes of Shankara and Patanjali (all of them are different, of course). The commonality is that there is often no simple way you could deduce logical thinking in their intellectual accomplishments. My question was whether the great reliance on intuition, which is often a surrogate for supremely honed technical skills, though not in obvious display, is worthy in itself, though one might admit that this characteristic sometimes falters if it is not supplemented by the rigours of a formal framework and logical analysis. In the Indian way of doing science, it worked supremely well where it did but one never knew where it would fail. My question was also motivated by the worry that the appeal to intuition was all but yielding place to formality in recent years, and to excel in that way requires one to be highly proficient technically. If one did not cultivate such mastery, the advantage was lost.

In particular, in Advaita, there is the focus on direct perception which,

it is always claimed, cannot be explored by any objective means. This declaration seemed to be a shortcoming to me. The greatest progress for humanity will be made, I thought, if direct perception can be explored by other means as well. Even though I have never seen anyone claim that by this means one will know Quantum Field Theory or the solutions of the Navier-Stokes equations, or any aspect of the material world, but that ability may help intuit the material world as well. If we can do that and also keep intact our ability to falsify our intuition, which is a hallmark of modern science, humanity will reach a refined level.

RN never fell into the trap of attempting to directly answer my poorly developed and muddled questions but we would occasionally, and fortunately for me, talk about similar things as he continued his serious quest on Indic epistemology. I cannot summarise his thinking adequately without further study but will try to present a partial view, as I understood it in various conversations. One has to remember that RN was well versed in Sanskrit (besides modern science and philosophy); in fact, about a year or so ago, he sent me a short email on how to accent Sanskrit words in English, something I had never learnt at school. He felt that his knowledge of Sanskrit was essential to the progress he made in this area.

## A "FALSE NARRATIVE"

RN made the case, in common with many other scholars, that the popularly held Western paradigm that science was created in Greece, declined in the so-called Dark Ages, was later revived and revolutionised in Europe at the beginning of the 16th century, is a false narrative, or at best a cartoon. Yet, to a modern science student, the heroes are European and American, although Indians are fortunate to have their own examples such as S. Ramanujan. J.C. Bose and C.V. Raman, just to name three. But why have others like Aryabhata and Bhaskara disappeared from the collective consciousness? Why does the world not know that the Pythagoras theorem was enunciated in India perhaps 300 years before Pythagoras (who himself may not have had anything to do with the theorem)?

RN got into such questions and studied them with deep attention, but would readily debunk false claims made by over-enthusiasts. For instance, he sided unambiguously with his younger colleagues H.S. Mukunda, S.M. Deshpande, H.R. Nagendra, A. Prabhu and S.P. Govindaraju when they debunked the false glorification of a non-existent ancient Indic technology on aeronautics. He was unerringly accurate in attributing nothing beyond what was justified, even to one of his heroes, Aryabhata. I once asked him if Aryabhata ever explicitly held the heliocentric view of our solar system. No, he said. He told me, in bits and pieces spread over several years, that while Aryabhata and the likes were comparable to the best in the history of science, their style of reasoning and their philosophy was different. What exactly was that? That was where my own question had started.

The ancient Greeks, RN said, indulged in conceptual models before attempting calculations and believed that they should be able to figure it all out by pure thought. The Indic methodology was primarily based on observation, experience and inference, while the Greek conception was based on deductive and axiom-based considerations. India was number-centric with algorithmic computing as the focus, and the Indic view emphasised calculation without insisting on *a priori* models. This philosophy served India until the 18th century or thereabouts. Both mathematically and technologically, the flow of ideas for several centuries was from the East to the West through the Arabs. The East, of course, included the Chinese, whose inventions dazzled the Europeans.

It was Francis Bacon who recognised the power of inventions and numbers. He blamed the Greeks for the sad state of European knowledge, and may well have been the first to equate knowledge with power (in contrast to the Indic notion that knowledge gives rise to freedom). In RN's words, though not in any specific order, what happened in the 16th and 17th centuries was that the meaning of mathematics changed in the West. Until then it was Euclid's geometry (borrowed back from the Arabs and their translations from the Greek). After that, it began to include numbers and algebra, both of which had come from India. Newton, in particular, mathematicised science. As Hermann Weyl said, Europe moved away from Greek ideas to follow a path that had originated in India, where the concept of numbers had been considered logically prior to the concept of geometry.

Finally, even though not all Indic scholars believed in mythology (e.g., Aryabhata said that Rahu and Ketu were pure nonsense and had figured out the correct reason for the eclipses—and he paid no price for that heresy from orthodoxy, unlike Galileo or, worse, Giordano Bruno had to, many centuries later). Yet, the otherwise great mathematician Brahmagupta was quite insistent on returning to the Rahu and Ketu model. This often made it difficult to discern intellectual gems from nonsense, as far as the framework went, though the computational results were the same.

## BEYOND SCIENCE

RN wrote extensively about these and other meticulous findings of his, and I have done a hasty job of presenting them here. But I hope it is enough to engage an interested reader with his writing and accomplishments. It suffices to say that I regard RN as a first-rate scientist who broke many barriers and accomplished an immense amount. His interests extended far beyond science. He was a leader, a scholar, a philosopher, and a thorough gentleman; we will miss him and his wisdom greatly. □

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