

## M. Vijayan (1941–2022)

M. Vijayan, one of India's pre-eminent biophysicists and a pioneer of macromolecular crystallography and structural biology passed away in Bengaluru on 24 April 2022. In his passing, the country has lost not only one of its most distinguished scientists, but also a passionate spokesman for science. The end came after a long and difficult struggle with a progressive neurodegenerative disorder, which left him physically incapacitated for several years but mentally alert to the very end. In his remarkably productive career that spanned over five decades, Vijayan was a researcher, teacher and administrator who greatly influenced his surroundings.

Mamannamana (he was fond of explaining the lilting pronunciation of his name) Vijayan was born in Cherpu, Thrissur, Kerala on 16 October 1941. His schooling and college years were spent in Thrissur. He graduated with a degree in physics from the Sree Kerala Varma College, an institution that Vijayan would later describe as 'liberal and conducive to politics'. Vijayan's passion in his college years was politics; the communist calling was irresistible in Kerala in the 1950s. His father had been associated with E. M. S. Namboodiripad, the legendary chief minister of Kerala in the 1950s. The young Vijayan came under the spell of another of Kerala's great political leaders, C. Achutha Menon. As a young man growing up in the heady days after independence, he was also an unabashed Nehruvian, very fond of quoting the famous lines, 'at the stroke of the midnight hour when the world sleeps, India wakes to freedom'. To him, Gandhi was a 'distant luminous icon, a godlike figure', to whom he could not personally relate, but felt a complete empathy with Nehru. In reflecting on Vijayan's life and times, I cannot help but note, that many scientists of his generation and those that preceded them were often driven by a sense of idealism that seemed to permeate the early years of India as a free democracy. Physics at college was less engaging than politics, but the romance of modern physics in the final year was irresistible. Some sage advice from Achutha Menon, later Chief Minister of Kerala, that a good student should not be wasted on local politics led Vijayan to Allahabad University in 1961 for a Master's degree. The physics department had a fine tradition set by Meghnad Saha. In later years, Vijayan would single out Sri Krishna

Joshi (later Director General CSIR and President, Indian National Science Academy) as the man who nudged him into physics, leading eventually to his entry into the Indian Institute of Science (IISc), Bangalore, in 1963 as a Ph.D. student. Vijayan had found his home. He would spend much of the next six decades at IISc, an institution that he loved and served with the utmost commitment. He was mentored in the emerging field of X-ray crystallography by a young faculty member at that time, M. A. Viswamitra and influenced by the Head of the Physics department, R. S. Krishnan,



who had succeeded C. V. Raman. The traditions of crystallography at IISc may be traced to the work of G. N. Ramachandran and S. Ramaseshan in the period between the late 1940s and 1950s. It was at IISc that Vijayan found his scientific calling and also his future wife, Kalyani, a fellow student in the crystallography laboratory.

Ph.D. in hand, Vijayan left for Oxford to work with Dorothy Hodgkin in 1968, on the structure determination of insulin. This was the turning point in his scientific career. Dorothy Hodgkin was a celebrated crystallographer, awarded a Nobel Prize in 1964 for her classic structure determinations of cholesterol, penicillin and Vitamin B-12. As a student with J. D. Bernal, she had also recorded the first X-ray diffraction photographs of the protein pepsin in 1934 and reported diffraction from insulin crystals in 1935. Insulin's remarkable glucose lowering properties had been discovered by Frederick Banting in 1921, resulting in the controversial award of the Nobel Prize to him and John Macleod in 1923. The three-dimensional structure determination of insulin was a difficult problem in the 1960s. The first contours of the structure of the protein myoglobin had appeared in 1958

(Kendrew) and haemoglobin followed in 1960 (Perutz). By the late 1960s only a handful of protein structures were available. Vijayan joined the insulin group at Oxford in January 1968 and was soon immersed in the excitement of the structure determination of insulin. It was at Oxford that he married Kalyani and formed deep and lifelong friendships with a band of scientists, who would push the discipline of protein crystallography forward; among them were Guy and Eleanor Dodson, Tom Blundell and Ted Baker, who along with Dorothy Hodgkin, visited Vijayan's laboratory at IISc on multiple occasions, beginning in the mid-1970s. The insulin structure appeared in 1969, a *tour de force* of the fledgling field of macromolecular crystallography (*Nature*, 1969, **224**, 491–495). The structure would be refined over the years and analysed to tease out the 'reflection of the structure in chemistry and biology'. A final overview appeared in 1988. In a brief history of protein crystallography, in a section entitled, 'Dorothy Hodgkin who put bio and crystallography together' there is a description: '.....most likely the longest paper in the history of protein crystallography, taking up a whole issue of *Philosophical Transactions of the Royal Society of London, Series B* (1988, **319**, 369–456). The co-authors of this monumental work, listed in alphabetical order and all trained by Hodgkin, include such well-known structural biologists as Ted Baker, Tom Blundell, Eleanor and Guy Dodson, and Mamannamana Vijayan, amongst others' (*FEBS J.*, 2014, **281**, 3985–4009).

By 1971, Vijayan was back in Bangalore, initially appointed in the Physics department, but soon to move, in 1974, to G. N. Ramachandran's newly formed Molecular Biophysics Unit (MBU) at IISc. It was here that I met Vijayan for the first time, almost half a century ago. Ramachandran had a formidable reputation, having carried out seminal work on the structure of the fibrous protein collagen and polypeptide conformations, resulting in the eponymous Map. His vision was to build a new department where experimental work on biological molecules would flourish, along with the well-established methods of theoretical conformational analysis. Ramachandran was indeed imagining the creation of a group that would transition from molecular biophysics to structural biology, although the term was not in vogue at that time. Vijayan

was a prize catch for the new department. The goal was to determine globular protein structures in Bangalore in the 1970s. There were however several hurdles to be overcome. MBU had no laboratories, no equipment and relatively little by way of funds. One of the early grants that we got was a project to determine the crystal structures of proline peptides from the Indian National Science Academy (INSA), an organization that Vijayan would preside over decades later. Vijayan and I were coinvestigators, receiving a grant of Rs 10,000, which we shared to the last rupee. Organized funding for science still lay in the future. The newly formed Department of Science and Technology (DST) would begin the process of supporting individual investigator initiated projects after peer review only in the early 1980s. The political climate was uncertain. The 1975–77 period was dominated by the declaration of the Emergency by Mrs Gandhi's government. I recall, Vijayan, still young and politically conscious, rushing in to tell me of the new development on 25 June 1975. In the early phase at IISc even as he dreamt of proteins, Vijayan threw himself, with characteristic energy, into the determination of the structures of complexes of amino acids. I recall the many heated and enjoyable discussions we had on the relevance of these interesting structures to the problem of the abiotic polymerization of amino acids in early chemical evolution, as a prelude to the origin of life on Earth. The Emergency years were followed by the turmoil of the Janata government during the period 1977–80, times that were hardly conducive to obtaining support for new instrumentation for research. It was also a time when even if money became available buying equipment from suppliers abroad required considerable paperwork to procure an import licence. The liberalized economy and the loosening of the rules for import of chemicals and equipment lay almost a decade into the future. To my inexperienced eyes, structure determination of proteins seemed a distant, and possibly inaccessible, goal. Vijayan was undaunted. He brought to the task of building a macromolecular crystallography laboratory enormous enthusiasm and unbounded energy. He was an incurable optimist and was quick to seize every emerging programme, introduced by the funding agencies in the 1980s, to create what arguably was the finest experimental facility in India at that time, albeit housed in modest surroundings; a far cry from the gleaming laboratories that now dot India's institutions.

The recruitment, into MBU in 1980–81, of Avadesha Suroliya, a protein biochemist specializing in lectins and M. R. N. Murthy, a crystallographer fresh from Michael Rossmann's laboratory at Purdue, provided Vijayan with the collaboration needed to launch into structure determination. Gene cloning and the production of recombinant proteins were more than a decade away. Lectins from plant sources, with their remarkable carbohydrate binding properties were an inspired choice for investigation. The first structure of peanut lectin, determined by multiple isomorphous replacement, appeared in 1994 (*Proc. Natl. Acad. Sci. USA*, 1994, **91**, 227–231), a dozen years after the preliminary characterization of the crystals (*J. Mol. Biol.*, 1982, **154**, 177–178) and twenty years after Vijayan's arrival in MBU; a tribute to his persistence and resilience. A second structure, jacalin, appeared in 1996 (*Nature Struct. Biol.*, 1996, **3**, 596–603). The flood gates were now open. Several structures that illuminated protein carbohydrate interactions followed. The value of structural information was beginning to be appreciated by the biochemists at IISc. Vijayan's laboratory had soon launched a programme on mycobacterial proteins. Even as structural genomics programmes blossomed abroad, Vijayan campaigned tirelessly for concerted Indian efforts on organisms that caused infectious disease in India. The students who cut their teeth on these structures began to spread out to many other centres in India, as the importance of structural biology grew and the instrumentation for crystallography became accessible in a large number of national laboratories and academic institutions. Vijayan also promoted the growth of bioinformatics and computational biology with vigour, even as the technologies of computation grew by leaps and bounds. In retrospect, Vijayan catalysed, promoted and ceaselessly supported the development of structural biology in India. In so doing, he realized Ramachandran's vision. Most fittingly, in 1999 when Ramachandran, unwell and unable to travel, was awarded the Ewald Prize by the International Union of Crystallography (IUCr) it was Vijayan who received the award on his behalf at the meeting in Glasgow and delivered the Ewald Lecture.

For many years, between 1985 and 2004, Vijayan contributed enormously to the administration at IISc. As Chairman of MBU (1985–1992) and Chairman of the Division of Biological Sciences (1992–2000) Vijayan promoted the establishment

of new centres and facilities, spearheading the drive to obtaining long-term support from the Department of Biotechnology and the Department of Science and Technology. Bringing faculty members together from diverse departments is not an easy task. Even the carrot of money sometimes proves insufficient to overcome territorial barriers. At a time when 'interdisciplinary research' was still an unfamiliar term, Vijayan used his formidable powers of persuasion to hammer together common proposals. He often won over opponents of his ideas by wearing them out; few had the energy or the conviction to maintain their positions. It was often easier to agree with him than to be persuaded over time by his persistence and enthusiasm for the task at hand. In 1998, he was considered the most likely person to become the Director of IISc. This was not to be. He coped, as few could have done, with the disappointment of being denied a position that he not only sought but indeed deserved. He accepted the position of Associate Director, shouldered considerable responsibility, and worked tirelessly, with intense commitment, for the betterment of IISc between 2000 and 2004, until he formally retired. It was during this period that Vijayan demonstrated his unwavering loyalty to the institution that had nurtured him. In his long stint in the Institute's administration, I had a ringside view of his clear thinking and ability to take firm decisions in difficult situations. He could be strict but kind. He had a fondness for the underdog, a holdover from his youthful fling with leftist ideologies.

Vijayan was an enthusiastic teacher, who for a long time conducted a course in which he would introduce the basic principles of crystallography. His energy invariably rubbed off on his audience. For years we would meet outside the classroom, as the unchanging timetable scheduled his lecture immediately after my own. There was always time for a brief exchange before he went in to start his class. As I walked away, I would often realize with a twinge of guilt that I had left my senior colleague with a board filled with chalk-drawn formulae, which he would now have to clean. He never complained.

Vijayan was a glutton for work. Unsurprisingly, he was much in demand all over India serving on a multitude of committees that oversaw grants and institutions and bodies with advisory functions. His organizational abilities were always visible and in demand. In his long career, Vijayan was widely recognized by his peers in the scientific community and by the Government.

In addition to the many Academy fellowships, medals, awards and professorial chairs that he received, he served with great distinction as the President of the Indian National Science Academy (2007–2009) and was conferred the Padma Shri by the Government of India in 2004. His home state of Kerala honoured him with the highest scientific awards, recognitions that he prized. In turn he served the state in many advisory capacities. Vijayan was always close to his roots frequently talking about life in Kerala.

For almost a decade before his passing, Vijayan was slowly exposed to the ravages of motor neuron disease. He never allowed his increasing physical disability to divert him from the activities that he loved: research, mentoring students and acting as a passionate advocate for the cause of basic science in India. Despite considerable restrictions to his mobility, he continued to come to his laboratory on the second floor of the MBU building at IISc with a regularity that was inspiring. Always a good writer, clear and forceful, Vijayan turned to Malayalam to first pen his account of his early years in Kerala. Encouraged by his ability to recollect and narrate, Vijayan wrote a complete account of his life in a memoir published in 2020 by INSA, Delhi

and reviewed in this journal (*Curr. Sci.*, 2020, **118**, 1997–1998). In trying to gather my thoughts for these reflections on Vijayan's life, I could not but marvel at his prodigious memory and the sense of fulfilment that seemed to permeate through the pages of his memoir. His skills as a writer are clearly on display in his description of the complexities of Kerala's social structures and his early experiences, as he flirted with the idea of a career as a political activist. Vijayan had a world view much broader than is common amongst professional scientists in India. In his memoirs he reflects on Darwinism and Marxism: '*Over decades Darwinism was creatively enriched and elaborated and remains the centrepiece of biology. Marxism to an extent became the ideology of the establishment with the advent of the Soviet Union and other socialist states. That substantially stunted the development of Marxist theory and its capacity to absorb new experiences. One casualty in the process was the near disappearance of Marxian humanism from the discourse. Even in the Oxford days, I used to feel the need for deliberate steps to free Marxism from the authoritarian framework and enrich it through creative intervention. This is particularly important in the present age of globalised, aggressive,*

*predatory capitalism*' (Vijayan, M., *A Life Among Men, Women and Molecules*, INSA, 2020, p. 58). Despite the constraints of his later years, Vijayan wrote several times in the columns of this journal, forcefully and compellingly, arguing for enhanced public support for science. Even a few months ago he presented a case for reforming the administrative and financial structures that are intended to promote science in India, but which often, sadly, exercise an inhibitory function. He summed up with a touch of regret: '*The approach of many of us has been to take full advantage of the positive features of Indian science, while trying to eliminate (it turns out rather unsuccessfully) the negative features*' (*Curr. Sci.*, 2021, **121**, 346–347).

Vijayan was a proud, loving, and devoted husband and father. He leaves behind his wife Kalyani and daughter Devayani. He also leaves behind a host of students, associates, friends, and colleagues whose lives he touched and enriched. It was a privilege to have known and worked with him.

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## T. V. S. R. Appa Rao (1941–2022)

Dr Tamirisa Venkateswara Sree Rama Appa Rao, a legend in the field of structural engineering passed away on 17 February 2022 in Hyderabad.

Rao, born on 7 February 1941, had a brilliant academic track record and an outstanding professional career. In 1962, he obtained first rank with a gold medal from Andhra University with a Bachelor's Degree (Honors) in Civil Engineering. Rao then earned the East-West Center Fellowship and pursued post-graduate studies at the University of Hawaii, USA; and obtained a Master's degree in structural engineering. In 1968, he obtained his Ph.D. degree from Cornell University, USA. During 1967–68, he worked as a post-doctoral research fellow at Cornell University, and thereafter had a brief stint as a consultant in the US.

Returning to India in 1969, Rao joined the team of the then Director, late G. S.

Ramaswamy at the Structural Engineering Research Centre (SERC), located on the campus of the CSIR-Central Building Research Institute in Roorkee. In the mid-1970s, SERC shifted to its present campus in Chennai. Seldom does an outstanding



young scientist morph into an institution-builder, manager and formulator of administrative policies, whose legacy will continue to be cherished and admired by the scientific community. Most would agree that Rao was indeed an exceptional personality. The few who may hesitate, would have to admire the resoluteness of a young engineering student who decided that he would go to the US for further studies, and return to head a research institution in a short time. This was a shining example of his commitment to contribute to the country's R&D efforts. His first research contribution as an SERC scientist on the stress hybrid technique of finite element method presented at the First International Conference on Structural Mechanics in Reactor Technology at Berlin, Germany, was the forerunner for further research in this area by scientists at the Massachusetts Institute of Technology, USA, and other institutions.