

## Ramesh Maheshwari (1940–2019)

For the love of an organism – there could be no more apt words than these to describe the life and work Prof. Ramesh Maheshwari, who passed away in Bengaluru on 30 March 2019 at 79 years of age, leaving behind his wife, son, daughter-in-law, and a host of students, disciples, colleagues and friends, all of whom knew him both professionally and personally, and who will truly mourn this loss. He was a mentor, teacher and friend to many, and an endless source of inspiration to some of us, even today.

Born in Dacca (presently Dhaka) on 19 December 1940 to Panchanan Maheshwari, a pioneering botanist of his times and remembered even now for his classic contributions to plant embryology, and Shanti Maheshwari, Ramesh first fell in love with fungi during his pre-doctoral research at Delhi University and even more deeply so when he went on to do a doctorate at the University of Wisconsin in Madison, USA, under the mentorship of Paul J. Allen and Albert C. Hildebrandt. His doctoral research concerned the structure, function and development of urediospores of the wheat stem rust *Puccinia graminis tritici*, and the mechanisms underlying the ability of its infective structures to penetrate through the stomata of the host and establish infection. And thus began a love affair that occupied Ramesh all his life and which led to a scientific crusade to comprehend the biology and life-histories of a variety of fungi, using a diversity of biochemical and genetic tools. After a brief postdoctoral stint with Alfred S. Sussman at the University of Michigan, USA, during which time Ramesh studied the biology of dormancy and germination of urediospores of the rust fungus, he joined the Department of Biochemistry at Indian Institute of Science (IISc), Bengaluru in 1972.

The Biochemistry Department at IISc was a Mecca for the study of enzymology, metabolism and biochemistry of DNA and RNA in the late sixties and seventies. As a young faculty, Ramesh was faced with a choice between two research areas, one that ultimately determined the trajectory of his career: studying enzymes and biochemical pathways in isolation in a test tube versus studying them in the context of an organism. It

took him a few years, but he chose the organism, and used biochemistry and enzymology as a tool to study the lives of fungi in their natural habitats. Looking back, it was a brave decision and a rare one. For Ramesh deeply believed – rather unusually in those exciting times when molecular biology had begun to make inroads into and consume Indian biology – that the life sciences were fascinating because they were all about living organisms and that he had a number of incisive tools that would help him understand how the fungi, which he



loved so much, survived, bred and evolved, often in rather difficult environments. And so began his long, arduous but a wonderfully fruitful career that would occupy him completely and passionately for the next 30 years.

Ramesh spent over two years collecting soils from different regions of southern India and established simple techniques to isolate a variety of fungi. By providing temperature-based selection, he was able to obtain and purify over a 100 different species of thermophilic fungi, around which he built his research programme. These fungi grew optimally at 60°C, a temperature not permissive for the growth of other eukaryotic life forms. A key area of research in Ramesh's laboratory was to understand the unique biochemistry that allowed thermophilic fungi to thrive under conditions that were off-limits to other eukaryotic forms.

The fungi that Ramesh isolated produced large quantities of extracellular enzymes that were purified to homogeneity, and were further analysed by sequencing, crystallography and other analytical methods across several laboratories in the Department of Biochemistry and Molecular Biophysics unit at IISc.

Detailed studies of these enzymes revealed their role in recycling complex biological materials in the natural ecosystem<sup>1</sup> which fascinated Ramesh, who would often remark that his fungi would outlive all other organisms because of their remarkable physiological and biochemical plasticity.

In 1988, Ramesh was awarded a Fulbright Fellowship to spend a year at Stanford University, USA, to work with David Perkins, one of the greatest classical fungal geneticists of our time and an individual Ramesh considered his guru – a position he held to be even above that of his parents<sup>2</sup>. Based on Ramesh's work at Stanford, the next phase of research in his laboratory became interdisciplinary – a fusion of classical genetics with traditional biochemistry – and he began to move from thermophilic fungi to *Neurospora*. Interestingly, however, Ramesh refused to become a molecular biologist and insisted on continuing to do his 'unfashionable' science. Moreover, he took a conscious decision never to visit any foreign laboratory again, not for 'research material or for material gains'. He worked on his organisms with a passion and involvement that was unparalleled, and *Neurospora* soon became his most beloved object of study. His enthusiasm during field trips was unbound and infectious. Seeing *Neurospora* growing on sugarcane stumps as pink pustules, and his attempts to understand the rationale for its existence and the underlying mechanisms of survival in the sugarcane fields of Mandya, Karnataka became a thrilling experience for everyone in the laboratory. What gave Ramesh the greatest joy was his ability to combine fieldwork with more controlled studies in the laboratory. His most important contributions to fungal biology thus undoubtedly remain his studies from these happy times, when he unravelled the role of fire, which farmers took recourse to in order to clear their fields of stubble, in the life-history of *Neurospora*, the importance of heterokaryosis in maintaining otherwise lethal mutations in the laboratory, or the phenomenon of fungal senescence ('the death of the immortals') involving certain mutations, including the famous *sen* mutation. All of these were continuing efforts to satisfy his

undying curiosity to fathom the life of fungi and the challenges they faced in their natural habitats<sup>3,4</sup>. As he once remarked, 'We had opportunities of learning a bit of Nature even if all our observations did not result in publications' – a reflection of the philosophy underlying his feverish pursuit of science.

Ramesh supervised 17 doctoral students during his tenure at IISc. All of us remember him as an excellent teacher, a passionate researcher and a voracious reader. Over the years, we, almost unconsciously, began to use a plethora of additional adjectives to describe him: an inspirational mentor, uncompromising scientist, affectionate teacher and an invaluable friend – one who never paid any heed to barriers of age or social hierarchy. His love for science was palpable through his lectures and in our day-to-day interactions with him, within the laboratory or in the Coffee Board at IISc. He would work late into the night along with us and continued to have dedicated bench space in the laboratory. He always took special care to see that we were able to present our research findings to a larger audience, and would often diligently groom us till well after midnight before our nervous presentations in conferences or departmental meetings. In one word, Ramesh was a perfectionist and he laboured hard to instil this quality in all his students. And he never did give up. One of the present authors (A.V.), in fact,

continued to receive enthusiastic e-mails from him till about three years ago exhorting her to continue work with a particular ecotype of *Neurospora*, suggesting techniques or eager to know the results of experiments that he recommended. He was, as could be expected, particularly keen that *Neurospora* research flourish in India.

In January 2001, a sudden cerebral stroke followed by a hospital-acquired infection left him wheelchair-bound, but he was irrepressible. He continued to remain remarkably active in academics, publishing a number of thoughtful essays on many different topics, including but not limited to fungal biology in the 21st century (2005), plant–fungus marriages (2006), Circadian rhythms in fungi (2007), lotus-inspired nanotechnology (2008), biofuels (2008) and plant sugars (2011). One of the present authors (A.C.) is proud and honoured to have collaborated with Ramesh on a remarkable book<sup>5</sup> he wrote to promote the study of his beloved fungi, both in India and internationally. This book covers the contribution of unicellular and filamentous fungi to major paradigm shifts in our understanding of biology – from the discovery of one gene–one enzyme hypothesis to the uncovering of the mechanisms underlying the eukaryotic cell cycle.

Ramesh's sudden passing away has left us and all his other students, who he mentored over the years, with a deep

sense of loss. We will always hold dear his instilling in us a deep enthusiasm for science, his ample demonstrations of the crucial need for scientific integrity at every level, the importance of the powers of observation and hypothesis generation in taking the scientific process forward, and the critical ability to unflinchingly communicate what we have discovered to the larger world, clearly and succinctly. We will always miss you, 'Sir', 'Boss', 'Professor'.

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AMITABHA CHAUDHURI<sup>1</sup>  
ALKA VYAS<sup>2</sup>  
ANINDYA SINHA<sup>3,\*</sup>

<sup>1</sup>*MedGenome Inc., Foster City, California, USA*

<sup>2</sup>*School of Studies in Microbiology, Vikram University, Ujjain 456 010, India*

<sup>3</sup>*National Institute of Advanced Studies, Bengaluru 560 012, India*

\*e-mail: anindya.rana.sinha@gmail.com