ing picture processing. His work on syntactic pattern recognition at Illinois University between 1961 and 1964 was path-breaking in this field. Following up on this, at TIFR, he developed a meta-theory and approach to the study of language behaviour that takes pragmatics as the point of departure rather than syntax or semantics. He logically argued that, from an evolutionary point of view, behaviour must have evolved to be put to specific uses, and therefore, use must define structure and mechanism and not the other way round. This line of investigation culminated in his epoch-making book, *Modeling Language Behaviour* that opened an alternative concept to the earlier works of Chomsky. Apart from a number of widely acclaimed research papers, he authored four books published by Springer Verlag in 1981, SAGE in 1998 and 2004, and Tata McGraw Hill in 2004.

To give a creative direction to early education of children, Narasimhan investigated the language behaviour environment that a child is exposed to in the very early stages (9 months to 3 years) of first language acquisition. This led to an important ethological study of language acquisition behaviour. Such first language acquisition was found to have close links to the orality–literacy contrast. He showed that pre-literate oral language behaviour differs from literate language behaviour and that the former, and not the latter, has correlations with genetically prewired behaviour.

Further, he showed that language acquisition in the two cases bears an analogy to the differences between connectionist AI and rule-based AI, the former defined to include non-literate modes of functioning which cannot be reduced to a 'puzzle-solving' mode. He wrote a thought-provoking book on this at the age of 77.

These studies have revealed new paradigms for nursery and primary education of children.

In the 60s and early 70s, Narasimhan was among the early workers in the area of computational modelling of visual behaviour and advocated structural models and a 'grammar' to analyse and describe what is in the visually given image. For this he was instrumental in the development of a special language called 'PAX'. A group at Illinois, of which he was a part, was putting massive effort to realize a retinal image processing hardware based on PAX and other principles. The project was far ahead of time, at least by four decades, and therefore was subsequently abandoned.

No largesse of conferment of awards and rewards like Fellowships of INSA, IASc, NAS, CSI or the Padmashree (1976), Homi Bhabha Award (1976), Om Prakash Bhasin Award (1988), Dataquest Life Time Achievement Award (1994) can do full justice to this great mind, which saw possibilities far ahead of time.

Now, with tremendous strides being made in nanoelectronics and nanocomputing, these nodal ideas of Narasimhan, which are still basic and valid, can be resurrected. The time is appropriate to begin the development of a nano-hardware with the concept behind PAX among others to design and build retinal image processing hardware. This would be a fitting tribute to Narasimhan.

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P. K. Maitra (1932–2007)

Pabitra Kumar Maitra (fondly known as PKM to his students and friends), a pioneer in the field of yeast biochemical genetics, passed away after a brain haemorrhage in a Kolkata nursing home on 4 September 2007. PKM retired as a Professor at the Department of Biological Sciences (earlier Molecular Biology Unit), Tata Institute of Fundamental Research (TIFR), Mumbai. Some of his later years of research were spent at IIT, Mumbai and Agharkar Research Institute, Pune.

PKM was born in 1932 in Mazda, a small town in Nadia District, West Bengal and attended school in Krishnagar in the same district. He obtained his Bachelor's, Master's and Ph D degrees from Calcutta University during the period from 1952 to 1960. His doctoral research, under the guidance of S. C. Roy at the Department of Applied Chemistry, dealt mainly with the biochemical regulation of certain metabolic pathways of *Streptomyces olivaceous*. PKM then joined the Johnson Foundation, University of Pennsylvania, USA where he worked with Britton Chance and Ronald Estabrook on the bioenergetics and regulation of cellular metabolic pathways, with particular

focus on baker's yeast, *Saccharomyces cerevisiae* as a model system. During this period he developed sensitive fluorometric assays for the enzymes and intermediates of the glycolytic pathway. These assays have since been used widely to monitor glycolytic reactions and their rates *in vivo*. A noteworthy outcome of these studies was the discovery of oscillations in this pathway.

After his return to India, PKM joined the Molecular Biology Unit at TIFR, as one of its first members in 1964. Here, he and his colleagues, notably Zita Lobo (whom he later married in 1997), worked on the biochemical genetics of *Escherichia coli* and *S. cerevisiae*. In an early investigation on the effect of ribosomal mutations on the fidelity of translation in *E. coli*, PKM discovered changes in the structure and kinetic properties of enzymes synthesized on mutant ribosomes. A lifelong obsession for PKM concerned the question of how metabolic flux was regulated and homeostasis maintained in cells when crucial enzymes in biochemical pathways such as glycolysis were greatly reduced or increased. PKM decided very early on to take an approach, which used

both biochemistry and genetics as its tools, to address this problem in both organisms. Soon after PKM characterized glucokinase activity in yeast, he and Lobo began their collaboration, which has led to our primary understanding of the genetics of glycolysis in yeast. Even as they examined the kinetics of glycolytic enzymes in yeast, PKM, along with Meher Irani, began the genetic dissection of glycolysis in *E. coli*.

The essential nature of the glycolytic pathway and general impermeability of phosphorylated intermediates in these organisms made it difficult to select mutants lacking enzymes required for both glycolysis and gluconeogenesis. Based on the logic that such steps would require metabolites at both ends for growth, PKM and his colleagues devised a clever scheme to isolate such mutants; in their selection they used glycerol (as glucose was found to be toxic to such cells) and an oxidative substrate, succinate, for the growth of these mutants. Later on, they used this scheme to isolate similar mutants in baker's yeast, a discovery that revolutionized yeast biochemical genetics. Their subsequent work, over more than twenty years, on the genetic and biochemical dissection of the yeast glycolytic pathway fetched PKM international recognition and made him and his group pioneers in the field of microbial carbohydrate metabolism.

The 2-deoxyglucose selection method of PKM and Lobo first showed that there were three genes – encoding two hexokinases and one glucokinase – that affected the first steps of glycolysis in yeast. It was also shown that, contrary to popular belief, glycolytic enzymes were not constitutive in nature, but were coordinately induced over their basal levels by an intermediate of glucose metabolism, which they, using an intelligent combination of genetics and biochemistry, suggested to be glucose 6-phosphate. Indeed, later work in other laboratories identified transcriptional activators of the genes coding for these enzymes. PKM's search for mutations affecting glucose transport and in the regulatory elements of 'glycolytic' genes led to the isolation and characterization of structural and regulatory mutations affecting almost all the enzymes of the glycolytic pathway. Notable among these were the isolation of regulatory mutations affecting the transcription of the pyruvate decarboxylase gene, identification of the structural and regulatory subunits of phosphofructose kinase, and the characterization and cloning of the two isozymes of phosphogluconate dehydrogenase. PKM's group turned to molecular genetics in the later years, though he always appeared to be slightly skeptical about the power of molecular techniques in unravelling some of the problems concerning the regulation of the glycolytic pathway. The glucose transporter in baker's yeast, another scientific obsession of PKM's, sadly, remained elusive to him, though he identified a protein of similar function in the fission yeast, *Schizosaccharomyces pombe*.

It is simply neither possible nor our intention to enumerate all of PKM's scientific contributions and evaluate their significance; suffice to say that his work unfolded many secrets of the Embden–Meyerhof pathway in bacteria and yeast. What became truly legendary were, however, the collaborative and mutually dependent efforts between PKM and Lobo that allowed them to isolate genes in many of the steps in glucose or alcohol utilization and characterize their structure and function. Moreover, they incisively used their genetic and biochemical knowledge to make predictions on the structure, function and regulation of other genes in related pathways, such as the pentose phosphate pathway; it is truly remarkable how many of their predictions were proved correct subsequently when these genes were cloned and analysed, many of them, in fact, by Lobo, PKM and their students.

PKM enjoyed his science thoroughly. His enthusiasm was infectious though to his yet uninitiated students, it could often be bewildering. We both remember (though our associations with him were separated by a gap of more than ten years) how he would come frequently to our workbench, perch himself on a stool, take a deep puff, and ask 'So, what's new?' in his typically quizzical manner, eyebrows raised characteristically. I (P.S.) would feverishly rack my brains, feeling guilty for not having anything new to present, little realizing at that time that he was only looking for an excuse to build up a stimulating discussion and any observation, however small, could have initiated one! Even though he spent only a relatively short period of time at the Agharkar Research Institute, PKM is remembered there even today for having completely rejuvenated the student community. He was a remarkable guide to his students, both academically and otherwise, and inculcated in them a philosophy of practising science that was strikingly different from what appears to be the norm in India today. He untiringly conducted his fluorometric enzyme assays and tetrad dissections at the bench, typically from 8.00 am to 10.30 pm, and was extremely proud of the fact that his scientific achievements did not depend, in the least, on the scientific findings of his students! He never failed to decline authorship on work that he felt he had not contributed enough to and, most important of all, zealously guarded his personal relationships with us from our professional interactions.

Apart from science, PKM was passionate about other good things in life – sports, particularly football, classical and folk music, literature and of course, food and Bengali sweets. He would often announce seminars on the applications of glycolysis to human life and serve 'rossogollas' that he had carried for the entire department all the way from Kolkata! How can one ever forget his presence in the erstwhile Molecular Biology Unit of TIFR – equally the penetrating questions that he asked at seminars, curled up in his favourite oversized cane chair in the corner of the 'Admiralty Room', or his mellifluous voice as he sang his favourite Bhatiali songs of the boatmen of Bengal right till the end of our typically noisy Unit parties.

To his colleagues and students, PKM will be always be remembered for his undying passion for science, a remarkable strength of character, a wry sense of humour and, of course, his indomitable spirit that made him fight all the misfortunes life had in store for him. Although he did not care for awards and honours, deriving pleasure solely from his scientific pursuits, he never failed to inspire others to achieve higher levels of excellence and integrity, be it in science or in other spheres of life. In many ways, PKM has changed our lives forever.

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