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ROBIN MILNER

1934–2010

Elected in 2008

“For fundamental contributions to computer science, including the development of LCF, ML, CCS, and the pi-calculus.”

BY TONY HOARE AND GORDON PLOTKIN

ARTHUR JOHN ROBIN GORELL MILNER, a founding father of theoretical computer science, died of a heart attack on March 20, 2010.

Robin was born to Muriel (née Barnes-Gorell) and John Milner (a colonel in the British Army) in Yealmspton near Plymouth in South Devon on January 13, 1934. He attended the historic English private school Eton College, where he developed his love of mathematics. He spent his two years of compulsory military service in the Royal Engineers, ending as a second lieutenant. He entered King’s College, Cambridge, as a scholar, obtaining the highest honors in mathematics; then he spent his final year studying philosophy. He had no secondary degree until the later awards of honorary doctorates at 10 leading universities in Europe.

His first year of employment (1959–1960) was as a mathematics teacher at Marylebone Grammar School. He then joined a major British computer manufacturer, Ferranti Ltd., to work as a programmer. In 1963 he was appointed a lecturer in mathematics and computing at the City University, London, where he acquired his lifelong interest in automata theory, programming languages, artificial intelligence, and the relationship of logic with computation. These topics formed the essential mathematical basis and motivation for his subsequent researches.

He left London in 1968 to begin a period of full-time research, first at the University in Swansea, Wales, and then at Stanford University, California. In 1973, he was appointed as a lecturer in computer science at Edinburgh University. With Rod Burstall, Matthew Hennessy, and Gordon Plotkin, he founded and then served as the first director of the world-famous Laboratory for Foundations of Computer Science. In 1990–1994 he resumed full-time research, supported by a senior fellowship from the national funding agency SERC. He moved to Cambridge University in 1995 as head of the Computing Laboratory, and retired in 2001, after 2 years as a research professor there.

Robin's research interests always lay at the very foundations of computer science. His theories were embodied directly in highly original computer programs written by him and his colleagues. They served initially as research and educational tools. His colleagues then contributed to the extension, standardization, and reengineering of the tools in support of an even wider community of researchers. Eventually Robin's ideas and the tools evolved into general-purpose design automation tools for software engineers. This progression foreshadowed the development of the current culture of open-source software.

A prime example of this progression was his implementation (beginning at Stanford, but mostly at Edinburgh) of an automated reasoning tool for Dana Scott's logic for computable functions (LCF). The experience of implementation led him to the design and implementation of the first practical functional programming language, ML (metalanguage). It incorporated the Hindley-Milner algorithm for inferring and checking the types of all the terms of the language, while allowing the programmer to declare new polymorphic types to suit the needs of different applications. His own application was the generation of logical proofs, whose validity was also ensured by type checking. These successful features of ML were widely reproduced in many subsequent proof engines that are now in widespread use, as both industrial and research tools. Examples are Mike Gordon's and John Harrison's versions of

HOL (higher-order logic), both used as design tools in the electronics industry.

Throughout his career at Edinburgh, Robin explored the foundations of concurrent and distributed programming. Each of his major projects repeated the progression described in the previous paragraphs. They represent three major milestones in the broadening of our understanding of the practice and study of concurrency.

The first milestone was his novel formulation of a calculus of communicating systems (CCS). This opened a new area of computer science research, which culminated in industrial-strength tools for design of interactive (cyberphysical) systems (for example, Kim Larsen and his colleagues' UPPAAL). He introduced the efficiently mechanized concept of bisimulation as a definition of the equivalence of programs; informally interpreted, it showed that for every pair of nonequivalent programs there is a test or experiment capable of revealing their difference. This is an elegant formal expression of a philosophical principle common to both scientific theories and engineering specifications.

His next accomplishment was the pi-calculus, which models dynamic reconfiguration of communication channels between concurrent processes, and defines a notion of structural equivalence in terms of algebraic axioms and proof rules. He was looking for a canonical calculus of concurrent computation, which would underlie not only CCS but also functional programming and even Turing machines. The pi-calculus has been applied to a diverse range of problems, including computer security and biological modeling.

Finally, in his retirement he continued to work on a new "bigraphical" model for reactive systems. He proposed it as a unifying foundation for a wide range of calculi, including the pi-calculus. It was the subject of his last book, and a full discharge of his lifetime commitment to the idea that computer science is a science as fundamental as physics, with the same power to change and be changed by mathematics.

Robin's services were in repeated demand for the comparative assessment of the research and teaching of the universities

in the UK, which provided a basis for differential allocation of government funds. He was the editor of no fewer than five journals in theoretical computer science. In 1990, he was founding chairman of the UK Distinguished Dissertations scheme in computer science, and in 2002 a founding member of the UK Computing Research Committee (UKCRC), which was later adopted by the British Computer Society as the core of its academic branch.

From 2003 he was joint leader with Tony Hoare of a series of discussions in the UK, working toward agreement on long-term goals for computer science research, including the possibility of Grand Challenge projects. It was inspired by the completion in that year of the Human Genome Project, and it later secured sponsorship by the UKCRC. Robin identified most strongly with the challenge posed by the prospect of ubiquitous computing which has now been realized by Data Centres and the Internet of Things. He proposed that the scientific understanding of the associated problems could be met by a structured hierarchy of mathematical models, similar to those which have been astonishingly successful in all established branches of science, and which have served as the foundation of effective design automation tools in all branches of engineering. The search for such models has intensified and continues to this day.

Robin was the recipient in 1991 of the A.M. Turing Award in recognition of his work on LCF, ML, CCS, and full abstraction, an important foundational concept in the study of programming language semantics. Other leading awards were the (British) Computer Society Technical Award for the development of Standard ML (1987), the ACM SIGPLAN Programming Languages Achievement Award (2001), the Royal Medal of the Royal Society of Edinburgh (2004), and the Distinguished Achievement Award of the European Association for Theoretical Computer Science (2005).

In 1988 he was elected as a founding member of the Academia Europaea, fellow of the Royal Society, and Distinguished Fellow of the British Computer Society. He was later elected to fellowships of the Royal Society of Edinburgh (1993) and

of the ACM (1994), and received a foreign membership of the Académie Française des Sciences (2005). In 2006–2007 he was awarded the Blaise Pascal Chaire Internationale de Recherche, which he held at the Ecole Polytechnique.

Robin's publications included *Edinburgh LCF: A Mechanised Logic of Computation* (with Mike Gordon and Chris Wadsworth; Springer, 1979), *Commentary on Standard ML* (with Mads Tofte; MIT Press, 1991), *The Definition of Standard ML* (with Robert Harper, David MacQueen, and Mads Tofte; revised edition, MIT Press, 1997), *A Calculus of Communicating Systems* (Springer LNCS, 1982), *Communication and Concurrency* (Prentice Hall, 1989), and *The Space and Motion of Communicating Agents* (Cambridge, 2009).

Robin bore his genius and his distinctions lightly. To his students, his followers, his colleagues, and his scientific rivals he extended his gentle kindness and his generous friendship. He was always a pleasure to be with.

Robin's idea of relaxation included household repair and embellishment. He possessed a comprehensive collection of woodworking tools, with which he made elegantly shaped handles for string-pull light switches, special-purpose shelving in his home, and even a new handle for a fridge. His most unusual product was a new wooden dial to replace the broken plastic dial of an old rotary dial phone. Each finger hole was lovingly sanded smooth.

In his student days, Robin played the oboe, cello, and piano, and considered a career in music. It was at a music camp in 1963 that he met his wife, the violin teacher Lucy Moor. They both loved music throughout their lives, and Lucy played the viola in an enduring and popular amateur string quartet. Robin died only a few days after her funeral. He was also predeceased by his son Gabriel. He is survived by his sister June, daughter Chloe (with daughter Amy), and son Barney (with daughter Jade).