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Daniel Quillen obituary

A US mathematician, he developed a key algebraic theory

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Daniel Quillen was awarded a Fields medal, the discipline's highest honour

The most important steps forward in mathematics come less often from solving a particular problem than from finding a new way of looking at a class of problems. The work of the American mathematician Daniel Quillen, who has died aged 70 after suffering from Alzheimer's disease, was of that rare kind. He transformed whole areas of his subject in a career spent first at the Massachusetts Institute of Technology (MIT), and then at Oxford.

His most distinctive contributions came in a torrent of exciting work produced at the Institute for Advanced Study in Princeton, New Jersey, in 1969-70. His proof of the Adams conjecture in topology, relating to the classification of mappings of one sphere on to another, made crucial use of Alexander Grothendieck's work in algebraic geometry. It led on to his creation of algebraic K-theory, nowadays a very active subfield of algebra and number theory, far from its roots in topology.

The conjecture was almost simultaneously proved by Dennis Sullivan, also using Grothendieck's theory, but in a quite different way. His proof opened up an unrelated new area of mathematics. By a quirk of history, a few years later a much more elementary proof of the Adams conjecture was found, not using Grothendieck's theory. Had this happened earlier, a lot of current mathematics might not have been invented.

Born in Orange, New Jersey, Quillen won scholarships to Newark academy, and then to Harvard, where as a graduate student he worked under Raoul Bott, before going to a post at MIT. From the warm, outgoing Bott, Quillen learned that one did not have to be quick to be an outstanding mathematician. Unlike Bott, who always insisted on having everything explained to him many times, Quillen did not seem slow to others, but he saw himself as a person who had to think everything out very carefully from first principles, and work hard for every scrap of progress. Charmingly modest about his abilities, he was nonetheless ambitious and driven.

Bott was a universal mathematician, contributing to many different areas of the subject while always preserving the perspective of a geometer, and Quillen, too, never confined himself to a "field". His most famous achievements were in algebra, but he somehow came at it from the outside. He was interested in almost all of mathematics, and in a lot of physics as well.

Grothendieck, Quillen's second great influence, is famous for his mystical conviction that a mathematical problem will solve itself when one has found by sufficient humble

attentiveness exactly its right context and formulation. He opened up one of the most magical panoramas of modern mathematics, connecting number theory and geometry, and his influence, as well as that of the MIT topologist Daniel Kan, showed in Quillen's first lastingly famous work.

This was published in 1967, soon after he had completed his PhD thesis on partial differential equations, but in a quite different area. In the previous two decades it had been discovered that "shapes" – the technical term is homotopy types – could be attributed to many algebraic and combinatorial structures with, at first sight, nothing geometrical about them. The way this had been done, however, remained piecemeal and ad hoc.

Quillen produced a systematic theory of what kinds of structures have homotopy types, and how they can be studied. At the time, these ideas attracted little attention outside a small band of enthusiasts. Most mathematicians thought he was carrying abstraction too far. But 30 years later, the theory was becoming widely used, and it remains central on the mathematical stage today.

Before his year at the Institute for Advanced Study, Quillen spent 1968-69 at its Parisian equivalent, the Institut des Hautes Études Scientifiques, where Grothendieck was a central figure. Quillen's work, though much influenced by Grothendieck's, has a different flavour. Both aimed for simplicity, but Grothendieck found it in generality, while Quillen's guiding conviction was that to understand a mathematical phenomenon one must seek out its very simplest concrete manifestation. He felt he was not good with words, but his mathematical writings, produced by long agonised struggles to devise accounts that others would understand, are models of lucid, accurate, concise expression. Throughout his life he kept a beautifully written record of the mathematical thoughts he had each day, and they form an extraordinary archive.

In 1978 Quillen was awarded a Fields medal, the discipline's highest honour. By then his interests had shifted back towards global geometry and analysis. His goal was to show that Alain Connes's non-commutative geometry, in particular his cyclic homology, then becoming important in analysis and quantum theory, can be understood by traditional geometry and topology. This task, in many different guises, occupied the rest of his career.

In the 1980s, Quillen made at least three outstanding contributions that will continue to shape mathematics: the concept of a "superconnection" in differential geometry and analysis, the invention of the "determinant line" as a tool in index theory, and the Loday-Quillen theorem relating cyclic homology to algebraic K-theory.

Early in the decade, Quillen decided that he wanted to be at Oxford, attracted especially by its leading mathematician, Michael Atiyah. After spending 1982-83 there, in 1984 he moved from MIT to Oxford as Waynflete professor, where he remained until retirement in 2006. (A joke at the time of his appointment had an MIT dean rushing to him with an offer to halve his salary.)

Quillen loved music, especially Bach, and met his wife, Jean, in the Harvard orchestra. They had two children before he completed his PhD, and went on to have another four. Although his hair turned white in his 20s, he never lost the look or the manner of a boy. He is survived by Jean, their four daughters and two sons, 20 grandchildren, and one great-grandchild.

• Daniel Gray Quillen, mathematician, born 22 June 1940; died 30 April 2011