Michael Francis Atiyah

English mathematician **Michael Francis Atiyah (**April 22, 1929 -) is one of the most renowned mathematicians of the 20th century and still a major force in the new century. His work spans many branches of mathematics, but especially topology, geometry and analysis. In many cases his contributions have laid the foundations for entirely new areas of research. He is particularly concerned with bridging the gap between mathematics and physics in quantum field theory. On May 24, 2000, Atiyah gave a lecture during the Millennium Meeting of the Clay Mathematics Institute of Cambridge, Massachusetts, held at the Collège de France, in which he discussed four of the Institute's Millennium Prize Problems, discussing their nature and history, whose solutions would profoundly affect fluid dynamics and high-energy physics. The Institute has set aside a seven million dollar prize fund for the solution of seven major unsolved mathematical problems, one million dollars allotted to each of the problems.

Atiyah was born in London to a Lebanese father and Scottish mother. His father Edward came to England to study at Oxford University, where he met and married Michael's mother Jean. His father worked for 20 years in the Sudan government, settled in England in 1945 and wrote several books including *The Thin Line,* which was made into a film by the French director Claude Chabrol. Michael recalled, "My father always knew I would be a mathematician. When we traveled when I was young, I would exchange pocket money for foreign currencies and always make a profit." His early education was split between Victoria College in Cairo and Manchester Grammar School in Manchester. After completing his compulsory military duty, Atiyah entered Trinity College, Cambridge, receiving his B.A. in 1952 and his doctorate in mathematics in 1954. He spent 1955 at the Institute for Advanced

Study in Princeton, returning to Cambridge as a Fellow of Pembroke College, until 1961, when he became a Fellow of St. Catherine's College, Oxford. From 1963 to 1969, Atiyah filled the prestigious Savilian Chair of Geometry at Oxford, and, in 1966, he was awarded the Fields Medal in Mathematics, given at each International Congress of Mathematicians for outstanding discoveries in mathematics by persons under 40 years of age.

In 1969, Atiyah was appointed professor of mathematics at the Institute for Advanced Study. After three years in Princeton, he returned to England, to become a Royal Society Research Professor at Oxford as well as a Fellow of St. Catherine's College. Atiyah, who was knighted in 1983, stayed put until 1990 when he became Master of Trinity College, Cambridge, and director of the newly established Isaac Newton Institute for Mathematical Sciences in Cambridge. That same year he was appointed President of the Royal Society, a post he held for six years. Atiyah has been active in promoting mathematics internationally. In 1978, he played an important role in setting up and chairing the European Mathematical Council that eventually led to the establishment of the European Mathematical Society. He has served as the President of Pugwash, an international organization of leading scientists seeking means to reduce the danger of armed conflict, focusing on nuclear disarmament, and fostering cooperative solutions for global problems. In a lecture "Science and Society," Atiyah remarked, "The situation in the Middle East – between Israel and Palestine; India and Pakistan – the crises between them come and go; and amidst all this the world is at risk."

Atiyah has published exemplary work in algebraic geometry, algebraic topology, index theory of differential operators, and the mathematics of quantum theory. He described his way of doing mathematics as follows: "Most of the mathematics takes place in my head: I don't write much on paper, not until it is all finished, and then as you're trying to go through it all and organize it, you explain it to somebody else, and that naturally evolves into a discussion, and then you focus on particular problems,

and so on. Mathematics is normally a solitary exercise. You sit and you think hard for an hour, it gets a bit boring, so a bit of social interaction adds a whole new dimension and makes life so much more interesting and attractive." The nature of Atiyah's work does not lend itself to easy explanations. If not much detail about his accomplishments is provided here, it is because it would be unfair to the reader and to the mathematics to attempt to trivialize it. Atiyah continues to be productive. His legacy is current so we don't enjoy the advantage of having mathematicians over many years translating his work into terms that can be understood by interested and intelligent amateurs. When Newton and Leibniz invented the calculus, only a very select number of individuals could understand it. It hadn't been sufficiently developed so that it could be readily understood, but today its nature is taught with relative ease to millions of students throughout the world.

Atiyah showed how the study of vector bundles on spaces could be regarded as the study of cohomology theory, called K-theory, whose name comes from a particular construction introduced by Alexander Grothendieck. In Atiyah's own words:

> "K-theory really arose out of algebraic geometry, but basically what it's concerned with is the interrelationship of topology and linear algebra, linear analysis. You study linear things, and you have linear things that depend on parameters, you study how they vary, and the topological implications of that. And K-theory is the formal outcome of that…. Geometry originally started with linear things. Linear things like curves. If you study tangent spaces to manifolds, they are families of flat things, they are families of vector spaces. So once you get from geometry, immediately you start worrying about things like families of vector spaces, and K-theory is the outcome."

The important point to take away from this incomplete discussion of Atiyah's work is that he tries to

reverse the trend that separates mathematicians and physicists. Theoretical physics needs advanced mathematics and with the help of individuals like Atiyah what once seemed to be divergent strands of knowledge, is once again merging in what is known as string theory, something the public will be hearing more about in the new century. Atiyah calls his work a continuation of Einstein's dream. "It [his work linking geometry and physics] will help us understand the forces of gravity, magnetism, and nuclear forces and give them geometric configurations."

Quotation of the Day: "It is hard to communicate understanding because that is something you get by living with a problem for a long time. You study it, perhaps for years; you get out and feel it in your bones. You can't convey that to anyone else. Having studied the problem for five years you may be able to present it in such a way that it would take someone else less time to get to that point than it took you. But if they haven't struggled with the problem and seen all the pitfalls, then they haven't really understood it." – Michael Atiyah