George Andrews elected to the National Academy of Sciences

On Tuesday, April 29, 2003 George Andrews was notified that he had been elected to the National Academy of Sciences. Established in 1863 by a congressional act of incorporation signed by Abraham Lincoln, the National Academy (NAS) is the nation's premier scientific honorary society, "called on to act as an official adviser to the federal government . . . in any matter of science or technology." He is the only member of the faculty of the Department of Mathematics to be honored by membership in the NAS.

George W. Eyre Andrews was born on December 4, 1938 and grew up on a farm fifteen miles outside of Salem, Oregon. For a time, he had contemplated a career in law or engineering, but graduated from Oregon State College in June 1960 with simultaneous B.S. and M.A. degrees in mathematics. He spent the 1960-1961 academic year at Cambridge University in England supported by a Fulbright Fellowship.

He returned to the United States in 1961 and enrolled in the graduate program in mathematics at the University of Pennsylvania, where 1961-1962 was a special year in number theory. Since Andrews was planning on studying prime numbers, he decided Penn would be his best choice for grad school. After learning about the enigmatic self-taught Indian mathematical genius Srinivasa Ramanujan however, his primary interest shifted to another branch of analytic number theory. He wrote his doctoral dissertation on the subject of Ramanujan's third order mock theta functions under the direction of the great Hans Rademacher. It was also Rademacher who introduced Andrews to the theory of partitions. Andrews completed his Ph.D. in 1964.

Andrews decided to accept an offer for a faculty position at Penn State, in part due to his desire to work with Penn State number theorists S. Chowla and Nathan Fine. He was appointed as an assistant professor of mathematics in fall 1964, received tenure and promotion to the rank of associate professor in 1967, and became full professor in 1970. In 1981 he was appointed Evan Pugh Professor of Mathematics.

Andrews' mathematical research over the past four decades has been very diverse. Although primarily considered a number theorist, his work has overlapped into other areas, including mathematical analysis, computer science, and theoretical physics. In fact, the honorary doctorate he received in 1998 from the University of Parma was in physics, in recognition for his work on statistical mechanics (see the *Penn State Math News* 2000).

Despite this diversity, one thread is common in much of Andrews' work: the influence of Srinivasa Ramanujan. From an early age, Ramanujan showed exceptional talent in mathematics. With no appropriate teacher available, it was up to Ramanujan to teach himself out of whatever books he could borrow, devoting virtually all of his time to mathematics and neglecting his other subjects. Locked within the confines of a rigid system, he failed to qualify for higher education. When he was 26, Ramanujan wrote to the eminent English mathematician G. H. Hardy of Trinity College, Cambridge University, including some of his results (but no proofs or indications of how he derived them). Hardy was extremely impressed, and a correspondence between the two men followed. Eventually, Ramanujan was able to accept Hardy's invitation to come to Cambridge to study and collaborate. Ramanujan became ill during his stay in England, and returned to his native India in 1919. He died at the age of 32 in 1920. In his last letter to Hardy, Ramanujan described a new collection of functions which he had discovered and named "mock theta functions," the same functions Andrews was to begin studying in his Ph.D. thesis years later.

In 1976, while visiting England, Andrews arranged to have a look at papers from the estate of the mathematician G.N. Watson which were deposited in the Trinity College Library. To his surprise and amazement, he found, in a box, a collection of about 100 sheets of paper, which he recognized to be written on in Ramanujan's handwriting. He realized that he had in his hands Ramanujan's work on the mock theta functions, which had been unknown to the mathematical community, aside from the one letter Hardy had received in 1919. Andrews had discovered what is usually referred to as "The Lost Notebook" of Ramanujan. Some have claimed the lost notebook was neither *lost* (since the papers had made their way safely from India to the Trinity Library), nor a *notebook* (since they are unbound sheets), but

these critics seem to miss the point. Even though the papers were catalogued as part of the estate of G.N. Watson, no one realized what a treasure trove they were. It took an expert in mock theta functions like Andrews to realize the papers' true significance.

Prime Minister Rajiv Gandhi presents Andrews with one of the first printed copies of the "Lost Notebook," December, 1987

Later, Andrews assessed that about 20 percent of the results contained in *The Lost Notebook* had been discovered by other mathematicians in the ensuing five decades, but the vast majority of results were new to the mathematical community. Ramanujan had only presented results, and as with his first letter to Hardy, gave no hint as to how he discovered them and provided no proofs. Since unearthing *The Lost Notebook*, Andrews, his colleague Bruce Berndt of the University of Illinois, and a number of Berndt's Ph.D. students have managed to provide proofs for many of Ramanujan's formulas. Berndt and Andrews are currently preparing an edited version of *The Lost Notebook*.

The tale of Andrews' discovery of *The Lost Notebook*, while perhaps one of the more colorful episodes in his mathematical life, is only one of his myriad mathematical accomplishments. Andrews has solved a number of long standing open questions in mathematics. In 1750, the great mathematician Euler wrote of a case of "misleading induction," a formula that worked for the first ten cases, but starting with the eleventh, failed to be true. In 1990 Andrews was able to explain why this was the case, and showed how the solution related to problems in statistical physics.

While an undergraduate student, the celebrated physicist Freeman Dyson defined a partition statistic (which he called the "rank") to help explain the behavior of a certain partition enumeration function. While everything worked fine in the simplest cases, in more complicated settings the rank failed to explain everything he hoped it would. Accordingly Dyson conjectured the existence of another, more subtle partition statistic, which he whimsically named the "crank." In 1987 Andrews, with his student Frank Garvan, identified and fully characterized the crank. Dyson commented, "Whatever the final verdict of posterity may be, I believe the crank is unique among mathematical functions in having been named before it was discovered."

To date, Andrews has published over 240 papers and written five books. He has edited seven others, including the voluminous two-volume collection of the works of Percy A. MacMahon. Andrews is one of the world's leading authorities on partitions, q-series, and hypergeometric functions, and has remained creative and active into his sixties. He has served as thesis advisor for 18 Ph.D. students and 16 masters degree students.

In addition, Andrews has served on journal editorial boards; numerous committees for the department, the Eberly College of Science, and the University, as well as for the American Mathematical Society; advisory panels for the National Science Foundation and for analogous granting agencies abroad; and been chairman of the Department of Mathematics twice, despite a professed lack of affinity for administrative work. As chairman during the mid-1990s, he helped bring into being Penn State's unique and very successful MASS program. He has also been an active critic of some recent trends in mathematics education, particularly certain aspects of calculus reform.

However there are many facets to George Andrews to which a formal article or CV cannot do justice. His students report that as a classroom lecturer, his clarity is unsurpassed. He always welcomes them, whether during office hours or an unscheduled "drop by," with a friendly "Come in and have a chair!" and an inviting, cheerful grim.

Prepared with the assistance of Andrew V. Sills, whose Ph.D. thesis advisor was George Andrews.