Robert D. MacPherson Receives Second NAS Award in Mathematics

Robert D. MacPherson has received the National Academy of Sciences Award in Mathematics, a prize of $5000 established by the AMS to commemorate the Society's centennial in 1988. Professor MacPherson was recognized for "his role in the introduction and application of radically new approaches to the topology of singular spaces including characteristic classes, intersection homology, perverse sheaves, and stratified Morse theory." The award was one of thirteen presented at the Academy's 129th meeting on April 27, 1992.

This is the second time the prize has been awarded; the first award went to Robert P. Langlands of the Institute for Advanced Study in 1988. The award is given every four years in recognition of excellence in the mathematical sciences as evidenced by work published within a ten-year period and has no other restrictions concerning age, citizenship, or branch of mathematical study.

The major sources of funds for the award are generous gifts to the Society from the late Morris Yachter and the late Sidney Henry Gould. Yachter was an applied mathematician and engineer and was an AMS member from 1957 until his death in 1990. Gould had a long history of association with the Society, serving as Executive Editor of *Mathematical Reviews* and as AMS Editor of Translations; he died in 1986.

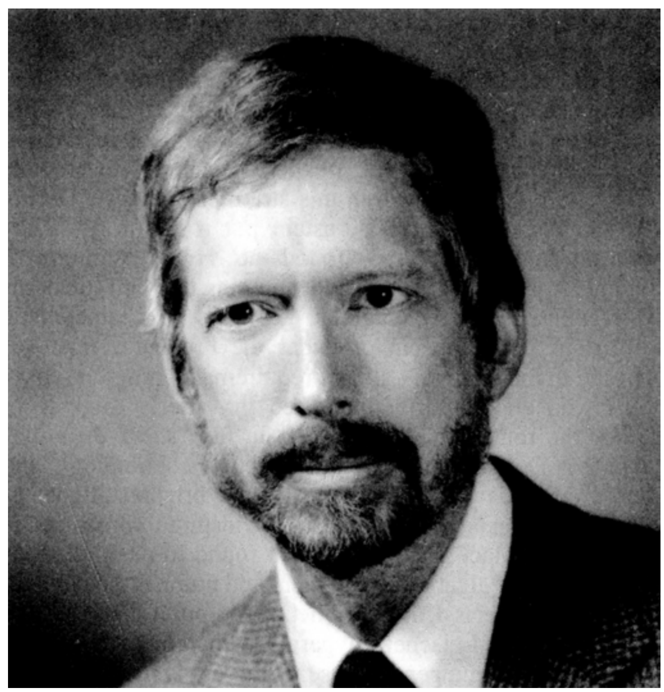
The committee choosing the 1992 awardee consisted of: William Browder (chair), Frederick W. Gehring, Richard G. Swan, and Daniel Gorenstein.

The Work of Robert D. MacPherson

The Managing Editor of *Notices* asked Raoul Bott of Harvard University to provide some comments on the work of Robert MacPherson. Professor Bott's response follows.

MacPherson was a graduate student at Harvard during the unruly years of the late 1960s, and it was my good fortune that he chose me as his thesis advisor. It soon became apparent that this at first rather shy young man had been blest with the gift of "seeing in all dimensions" to a quite unusual degree. My only task was to help him to communicate this vision to us less sighted ones. This gift is apparent in all of MacPherson's work, from his thesis on the characteristic classes of the singularities of maps, to his latest preprints, in collaboration with Fulton, on configuration spaces.

One of the most exciting instances in the pure mathematics of this century, as experienced by my generation, was surely the advent of sheaf theory in the 1940s and 1950s, which, in its various guises, forged links between topology, analysis, algebraic geometry, and number theory. Still, these new insights were clearly discernable only in the realm of nonsingular varieties and smooth manifolds. What was missing, and what to a large extent we now have, is an extension of this understanding into the much larger and, in so many cases, quite *unavoidable* domain of singular manifolds and stratified spaces.



Robert D. MacPherson

MacPherson has been one of the true pioneers of this step forward. His early work on singularities led him first to questions on characteristic numbers of singular spaces and then to one of his early achievements: the solution of a conjecture by Grothendieck and Deligne concerning characteristic classes of constructible sheaves. Soon thereafter, MacPherson started his very productive collaboration with

Baum and Fulton, and together they were able to formulate and prove a quite general statement of the Riemann-Roch theorem. But undoubtedly the centerpiece of the new understanding of stratified manifolds was the discovery of "intersection cohomology" by Goresky and MacPherson, which, according to the excellent survey article on this subject by Kleiman in *A Century of Mathematics in America Part* II, took place at the Institut des Hautes Etudes Scientifiques in the fall of 1974. Goresky was MacPherson's student at that time, and their wonderful collaboration has continued to this day.

At the center of our early understanding of the topology of manifolds stands the phenomenon of Poincaré duality. This hidden symmetry of the cohomology of a locally Euclidean space had already been discovered by Poincaré and is most easily formulated for compact orientable manifolds, where it asserts that: $H^n(M) \simeq H_{m-n}(M), m = \dim M$, or put differently: in complimentary dimensions, cohomology is in natural duality on such manifolds. In fact, one of the great driving forces of early sheaf theory was precisely the wish to produce a natural proof of this theorem, and to understand its implications in other more general situations, i.e., noncompact manifolds, local systems, etc. This symmetry was lost—one used to think irrevocably—once M acquired singularities.

The first great surprise of intersection cohomology was therefore that, by redefining the notion of chain and cycle for a stratified space, one could produce a new cohomology which agreed with the old notion in nonsingular instances, which did not depend on the stratification, and which satisfied Poincaré duality even on compact singular varieties. This in itself already achieved a goal set earlier by Dennis Sullivan—another of the gifted "seers" of this generation—to produce a "signature theorem" within this stratified category. During a recent conversation, J. Bernstein put it this way, "They (Goresky and MacPherson) found the '*right*' definition of cohomology." Bernstein was here applying the high standards of "*right*" exacted by algebraic geometry in characteristic p—that is, correct behavior under the Frobenius map—as opposed to the relatively simple requirements posed by those of us who are primarily interested in varieties over $\mathbb{R}$ or $\mathbb{C}$. For the remarkable fact is that in the "sheaf theoretic" guise that Deligne later gave intersection cohomology, and after prodigious work by many of the brightest lights of their generation, the $\mathbb{R}$-geometrically inspired constructs of Goresky and MacPherson were also found to meet all these requirements of algebraic geometers and number theorists. In particular, the "classical" Lefschetz fixed point theorem, and the two famous Lefschetz hyperplane theorems, were now also extended to the general case! But there is more: In some sense, wherever one could not get away from singularities, it turned out that the intersection cohomology behaved correctly. Over $\mathbb{R}$ it seems to yield the L^2 cohomology; with its aid, the Kazhdan-Lusztig conjectures in representation theory are solved; and it is also only in this context that the "Riemann-Hilbert problem" concerning the monodromies of differential equations finds its perfectly canonical formulation and solution.

Intersection cohomology, as well as the personal interactions of MacPherson with so many principals, has therefore played a decisive part in these cumulative achievements of the sheaf theory of the 1980s.

Of course, there is always a price to be paid for a deep understanding of so large and complicated an area of mathematics. It is paid in terms of the abstraction of the concepts and of the language. Thus, in this instance, the final clarity is only achieved in the realm of "perverse sheaves" or rather the derived category of complexes of such sheaves! But for the pilgrim of such a steep ascent there is vouchsafed, in the words of J. L. Verdier, a perfect category, a veritable "Paradise"!

MacPherson's interests really extend to all areas of mathematics, and his selfless devotion to our subject makes him an ideal and natural collaborator. The National Academy is to be congratulated for selecting him as their 1992 Prizewinner.

Biographical Sketch

Robert D. MacPherson was born in 1944 in Lakewood, Ohio. He received his B.A. from Swarthmore College in 1966 and his Ph.D. from Harvard University in 1970. He went to Brown University as a J. D. Tamarkin Instructor in 1972. By 1977 he had advanced from assistant professor to professor at Brown, and in 1985 he was named Florence Pirce Grant University Professor. In 1987 he moved to the Massachusetts Institute of Technology where he is currently chairman of the Pure Mathematics Committee.

Professor MacPherson has held numerous visiting positions at institutions all over the world, including the Institut des Hautes Etudes Scientifiques (IHES), Bûres-sur-Yvette (1974–1975, 1980–1981, Spring 1986); the Université de Paris VII (1976–1977); the Steklov Institute of Mathematics, Moscow (Fall 1980); the Consiglio Nazionale della Ricerche, Rome (Spring 1985); the Institute for Advanced Study, Princeton (Fall 1985); the University of Chicago (Fall 1991); and the Max-Planck Institut Für Mathematik, Bonn (Spring 1992).

Professor MacPherson presented the Hermann Weyl Lectures at the Institute for Advanced Study in Princeton in 1982 and the AMS Colloquium Lectures at the Joint Mathematics Meetings in San Francisco in January 1991. He delivered a plenary address at the International Congress of Mathematicians in 1983 in Warsaw. In addition, he presented the Unni Namboodiri Lectures at the University of Chicago in 1987 and the Hans Rademacher Lectures at the University of Pennsylvania in 1990.

Professor MacPherson was elected to the National Academy of Sciences and the American Academy of Arts and Sciences in 1992. He serves on the Advisory Committee for the Mathematical Sciences of the National Science Foundation. Well known for his concern for the Russian mathematical community, he is currently chair of the AMS Former Soviet Union Aid Fund Advisory Committee. He has donated his $5000 prize to the AMS fSU Aid Fund.