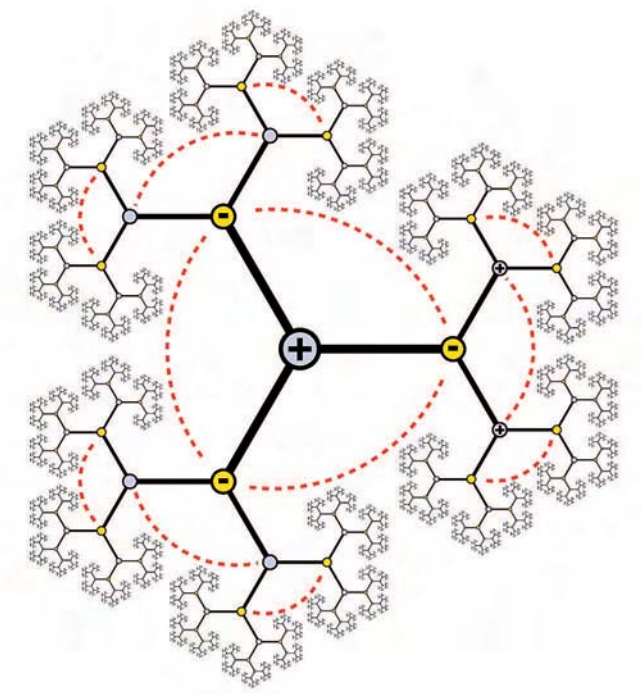
IAS
The Institute Letter
Summer 2010



The proof of the fundamental lemma by Bao Châu Ngô that was confirmed last fall is based on the work of many mathematicians associated with the Institute for Advanced Study over the past thirty years. The fundamental lemma, a technical device that links automorphic representations of different groups, was formulated by Robert Langlands, Professor Emeritus in the School of Mathematics, and came out of a set of overarching and interconnected conjectures that link number theory and representation theory, collectively known as the Langlands program. The proof of the fundamental lemma, which resisted all attempts for nearly three decades, firmly establishes many theorems that had assumed it and paves the way for progress in understanding underlying mathematical structures and possible connections to physics.

The simplest case of the fundamental lemma counts points with alternating signs at various distances from the center of a certain tree-like structure. As depicted in the above image by former Member Bill Casselman, it counts 1, 1−3=−2, 1−3+6=4, 1−3+6−12=−8, etc. But this case is deceptively simple, and Ngô's final proof required a huge range of sophisticated mathematical tools.

The story of the fundamental lemma, its proof, and the deep insights it provides into diverse fields from number theory and algebraic geometry to theoretical physics is a striking example of how mathematicians work at the Institute and demonstrates a belief in the unity of mathematics that extends back to Hermann Weyl, one of the first Professors at the Institute (see articles, pages 1 and 5). This interdisciplinary tradition has changed the course of the subject, leading to profound discoveries in many different mathematical fields, and forms the basis of the School's interaction with the School of Natural Sciences, which has led to the use of ideas from physics, such as gauge fields and strings, in solving problems in geometry and topology and the use of ideas from algebraic and differential geometry in theoretical physics.

It also poignantly underscores the Institute's continual commitment to the philosophy of Abraham Flexner, founding Director of the Institute, who argued the case for curiosity-driven rather than objective-driven research and emphasized the "usefulness of useless knowledge." It was his belief that if the Institute "eschews the chase for the useful, the minds of its scholars will be liberated, they will be free to take advantage of surprises, and someday an unexpected discovery, apparently leading nowhere, will be found to be an indispensable link in a long and complex chain that may open new worlds in theory and practice."

IAS

The Institute Letter

Institute for Advanced Study — Summer 2010

The Fundamental Lemma
From Minor Irritant to Central Problem

ANDREA KANE

Member Bao Châu Ngô's proof of the fundamental lemma was confirmed last fall.

The fundamental lemma has been described as a gross understatement.[1] "The curious thing is that it is called a lemma [a subsidiary proposition to be proved on the way to demonstrating a principal proposition]. It is a theorem," says Andrew Wiles, a Visitor in the School of Mathematics and an Institute Trustee. "At first, it was thought to be a minor irritant, but it subsequently became clear that it was not a lemma but rather a central problem in the field."

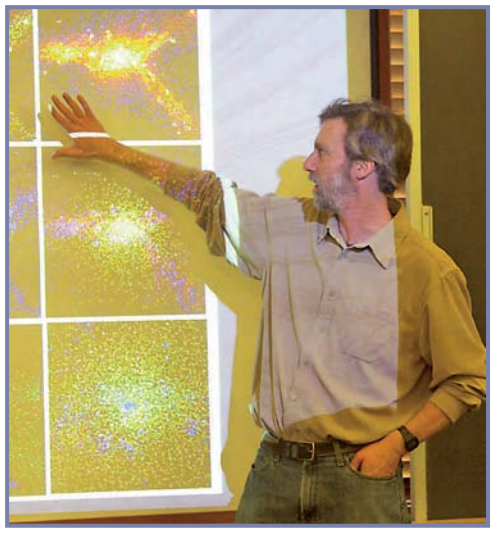
Robert Langlands, Professor Emeritus in the School of Mathematics, first introduced the fundamental lemma in 1979 in a lecture, "Les débuts d'une formule des traces stable," at the École Normale Supérieure de Jeunes Filles and published in *Publications Mathématiques de l'Université Paris VII*.[2] The goal of the lecture was the stabilization of the Selberg trace formula, but it also introduced the fundamental lemma, a technical device that links automorphic representations of different groups and the notion of closely related transfer factors that could transport automorphic forms. This led to the creation of a field of study that Diana Shelstad, a former Member in the School of Mathematics and Langlands's student, eventually called "endoscopy."

In the theory of endoscopy, the Selberg trace formula (introduced by the late Atle Selberg, Professor in the School of Mathematics) is used to distinguish the internal

(Continued on page 4)

Measuring the Cosmos, Mapping the Galaxy, Finding Planets

BY DAVID H. WEINBERG



ANDREA KANE

Member David H. Weinberg, Project Scientist of the Sloan Digital Sky Survey-III, gave a seminar on computational cosmology and galaxy formation in March.

Why is the expansion of the universe speeding up, instead of being slowed by the gravitational attraction of galaxies and dark matter? What is the history of the Milky Way galaxy and of the chemical elements in its stars? Why are the planetary systems discovered around other stars so different from our own solar system? These questions are the themes of SDSS-III, a six-year program of four giant astronomical surveys, and the focal point of my research at the Institute during the last year.

In fact, the Sloan Digital Sky Survey (SDSS) has been a running theme through all four of my stays at the Institute, which now span nearly two decades. As a long-term postdoctoral Member in the early 1990s, I joined in the effort to design the survey strategy and software system for the SDSS, a project that was then still in the early stages of fundraising, collaboration building, and hardware development. When I returned as a sabbatical visitor in 2001–02, SDSS

(Continued on page 6)

Reflections on the Dewey Seminar Experience

BY ANNA MARIE SMITH

In my discipline, political theory, we love a good story. We tell each other stories about the lives and times of great thinkers, such as Plato, Jefferson, or Gandhi. We enter into the fictitious worlds like the state of nature in Hobbes, Locke, and Rousseau. Like unruly bit players on the cast of a low-budget science-fiction film, we wander around the authors' otherworldly sets, poking and prodding at their fantastic creations. We take their conceptual vehicles out for snappy test drives, we throw fancy wrenches into their scripts by conducting unauthorized improvisations, and we try out alternative endings.

We hope that our storytelling will have, in the end, some practical application. When it seems that we are losing credibility with our audience, we usually try to bolster our claims about the practical relevance of our work by spinning another yarn or two.

Sometimes, however, we storytelling philosophers are invited to work with hands-on practitioners. These are the folks who perform the magic that really matters.

CLIFF MOORE

Anna Marie Smith, Rosanna and Charles Jaffin Founders' Circle Member in the School of Social Science, during a meeting of the Dewey Seminar, where discussions might center on approaches to science education, barriers to graduation at community colleges, or the level of control given to local school boards

They are actually trying to work out concrete solutions to the problems related to our key concepts—abstract ideas such as "justice," "equality," or "democracy"—on the ground, with real live people, ticking clocks, laws that bind, and ever-shrinking budgets.

In the past year, I participated in the Dewey Seminar on education in the School of Social Science. About a century ago, John Dewey wrote landmark works that, among other things, made the case that public education can play a crucial role in producing individuals who are well prepared to make thoughtful and knowledgeable contributions to society, not only as wage-earners, taxpayers, and the heads of families, but as citizens as well. Conceived by Danielle Allen, UPS Foundation Professor at the Institute, and Professor Rob Reich of Stanford University, the Dewey Seminar was designed to foster research on the complex relationships between education, schools, and the state.

The Dewey Seminar resembled a three-ring intellectual production. In one ring, we had a group of Members in the School of Social Science: a collection of political

(Continued on page 9)

News of the Institute Community

DIDIER FASSIN, James D. Wolfensohn Professor in the School of Social Science, has edited *Contemporary States of Emergency: The Politics of Military and Humanitarian Interventions* (Zone Books, 2010), with Mariella Pandolfi, Professor at the University of Montreal. In the book, anthropologists, legal scholars, and political scientists examine the historical antecedents that have made military and humanitarian interventions possible today. They also address the practical process of intervention in global situations on five continents, and investigate the ethical and political consequences of generalizations of "states of emergency." Fassin contributed a chapter titled "Heart of Humaneness: The Moral Economy of Humanitarian Intervention."

HELMUT HOFER, Professor in the School of Mathematics, has been elected to the German Academy of Sciences Leopoldina.

ERIC S. MASKIN, Albert O. Hirschman Professor in the School of Social Science, has been awarded the Centennial Medal of the Graduate School of Arts and Sciences of Harvard University, and he gave the Zvi Griliches Memorial Lectures at the New Economic School in Moscow. Maskin and PIERRE DELIGNE, Professor Emeritus in the School of Mathematics, were awarded the degree of Doctor Honoris Causa by the Free University of Brussels in May.

THOMAS SPENCER, Professor in the School of Mathematics, is among the seventy-two new members elected to the National Academy of Sciences.

SCOTT TREMAINE, Richard Black Professor in the School of Natural Sciences, has been awarded an honorary Doctor of Science degree from the University of Toronto.

Contents

Questions and comments regarding the *Institute Letter* should be directed to Kelly Devine Thomas, Senior Publications Officer, via email at kdthomas@ias.edu or by telephone at (609) 734-8091.

Issues of the *Institute Letter* and other Institute publications are available online at www.ias.edu/about/publications.

EDWARD WITTEN, Charles Simonyi Professor in the School of Natural Sciences, has been awarded the Lorentz Medal by the Royal Netherlands Academy of Arts and Sciences for his pioneering contributions to the mathematical description of fundamental forces and elementary particles, particularly within string theory. Witten has also been awarded the Isaac Newton Medal by the Institute of Physics for his profound contributions that have transformed areas of particle theory, quantum field theory, and general relativity. Witten received the award in London at a meeting of the Institute of Physics at which he gave the Isaac Newton Lecture on "String Theory and the Universe."

Harvard University Press has published new editions of *The Histories* by Polybius, volumes 1 and 2 (Loeb Classical Library), translated by W. R. Paton and edited by CHRISTIAN HABICHT, Professor Emeritus in the School of Historical Studies, and F. W. Walbank. The editions include corrected Greek text, explanatory notes, and a new introduction.

MARTIN REES, a cosmologist, astrophysicist, and Institute Trustee, has been awarded Rockefeller University's Lewis Thomas Prize for Writing about Science for 2009. The award recognizes Rees's book *Just Six Numbers: The Deep Forces That Shape the Universe* (Basic Books, 2000). Rees is Professor Emeritus of Cosmology and Astrophysics and Master of Trinity College at the University of Cambridge.

PAUL MORAVEC, former Institute Artist-in-Residence (2007–08) and Artistic Consultant (2008–09), was elected a Member of the American Philosophical Society. Moravec is University Professor at Adelphi University.

GRAHAM FARMELO, a Director's Visitor (2010), has received the Los Angeles Times Book Prize for Science and Technology for *The Strangest Man: The Hidden Life of Paul Dirac, Mystic of the Atom* (Basic Books, 2009), which he worked on during his time at the Institute.

TARIK O'REGAN, a Director's Visitor (2010), will premiere *Latent Manifest*, a piece commissioned by the BBC and composed largely at the Institute, on August 14 at the Proms classical music festival at the Royal Albert Hall in London.

JEFFREY R. HENIG, Member (2009–10) in the School of Social Science, has received the Outstanding Book Award from the American Educational Research Association for *Spin Cycle: How Research Is Used in Policy Debates: The Case of Charter Schools* (Russell Sage Foundation and the Century Foundation, 2008).

WARWICK H. ANDERSON, former Member (2005–06) in the School of Social Science, has been awarded the 2010 William H. Welch Medal of the American Association for the History of Medicine for his book *The Collectors of Lost Souls: Turning Kuru Scientists into Whitemen* (Johns Hopkins University Press, 2008). Anderson, who worked on the book during his time at the Institute, is a Professorial Research Fellow in the Department of History and the Centre for Values, Ethics and the Law in Medicine at the University of Sydney.

DAVID W. ANTHONY, former Member (2006) in the School of Historical Studies, has been awarded the Society for American Archaeology's 2010 Scholarly Book Award for *The Horse, the Wheel, and Language: How Bronze-Age Riders from the Eurasian Steppes Shaped the Modern World* (Princeton University Press, 2007), which he finished during his stay at the Institute. Anthony is a Professor of Anthropology at Hartwick College.

JAMES BINNEY, former Member (1983–87, 1989) in the School of Natural Sciences, has been awarded the Dirac Medal of the Institute of Physics. Binney is Professor at the Rudolf Peierls Centre for Theoretical Physics of the University of Oxford.

BENJAMIN CLAUDE BROWER, former Member (2007–08) in the School of Social Science, has been awarded the David H. Pinkney Prize by the Society for French Historical Studies for the best book of 2009 for *A Desert Named Peace: The Violence of France's Empire in the Algerian Sahara, 1844–1902* (Columbia University Press, 2009). Brower is Professor of History at the University of Texas at Austin.

FERGUS MILLAR, former Member (1968, 1983–84) in the School of Historical Studies, was knighted for services to scholarship in the Queen's Birthday Honors in June. Millar is Emeritus Camden Professor of Ancient History at the University of Oxford.

INEKE SLUITER, former Member (1996–97) in the School of Historical Studies, is one of four Dutch researchers to be awarded the 2010 Spinoza Prize, which carries an award of 2.5 million euros to fund research. Sluiter is currently Professor of Greek Language and Literature at Leiden University.

The Norwegian Academy of Science and Letters has awarded the 2010 Abel Prize to JOHN TORRENCE TATE, former Member (1959) in the School of Mathematics, for his lasting impact on number theory. Tate is Professor Emeritus of Mathematics at the University of Texas at Austin.

A Community of Scholars

In its eightieth year, the Institute for Advanced Study is endeavoring to create an online presence for its community of scholars, more than six thousand historians, mathematicians, scientists, and social scientists around the world who have benefited from membership.

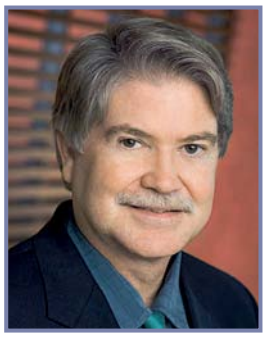
A list of scholars formally affiliated with the Institute from its founding in 1930 up to the present day has been published on the Institute's website at www.ias.edu/people/cos. Earlier this year, letters from the Director, Peter Goddard, were sent to Institute scholars describing the online project and providing instructions for submitting biographical and bibliographical information via an online form. Scholars are encouraged to continue to update their information now and into the future, as the project is an ongoing effort to record the scope and depth of the Institute community and its history. Submitted information will be published online in the near future; notifications will be sent once it is available. Should you have questions regarding A Community of Scholars, please contact cos@ias.edu. ■

Two New Trustees Appointed to Institute Board

E. Robert Fernholz

E. Robert Fernholz, Founder and Chief Investment Officer of INTECH, and John S. Hendricks, Founder and Chairman of Discovery Communications, have been elected to the Board of Trustees of the Institute for Advanced Study.

Fernholz began his career as a mathematician at the University of Washington, and later held Professorships at City University of New York, Universidad Nacional de Buenos Aires, and Princeton University. Fernholz became Research Director at Arbitrage Management Company in 1980, and in 1987 he founded INTECH, an institutional equity management firm. The INTECH portfolio process is based on mathematical methods introduced by Fernholz in the 1980s and later elaborated in his monograph *Stochastic Portfolio Theory* (Springer 2002). Fernholz and his wife, Luisa, founded the Minerva Research Foundation in 1993 to promote research in mathematical and statistical sciences and to encourage the participation of women in these disciplines. Luisa Fernholz directs the foundation, which has given support to the Institute's School of Mathematics since 2007.



ROBERT SEVERI

John S. Hendricks

Hendricks established the Cable Education Network, Inc., the predecessor of Discovery Communications, Inc., in 1982, and he launched the Discovery Channel in 1985. Under Hendricks's leadership, the company has grown into a global enterprise, with operations in more than 180 countries and territories and more than 1.5 billion subscribers. The company's twenty-eight network entertainment brands include TLC, Animal Planet, and Science Channel. Hendricks was recognized by the National Education Association for "greatly expanding educational opportunity for America's schoolchildren." Hendricks and his wife, Maureen, provide grant support for science research and higher education through the John and Maureen Hendricks Charitable Foundation. Hendricks recently established the Experius Academy to support adult lifelong learning through online courses and retreats.

Three members of the Board have been named Trustees Emeriti. Richard B. Black, President and Chief Executive Officer of ECRM Incorporated, is the outgoing Vice Chairman of the Board and served as a Trustee since 1990. Martin A. Chooljian, President of CH Capital Investments, served as a Trustee since 1997. James D. Wolfensohn, Chairman and Chief Executive Officer of Wolfensohn & Company, served as a Trustee since 1979 and was Chairman of the Board from 1986 to 2007. ■

Institute Marks Its Eightieth Year with Fall Celebrations

To celebrate its eightieth anniversary, the Institute for Advanced Study has planned two weekends, each of which will illustrate the work of two of its Schools and present opportunities for former Members and others to return and meet current Members and Faculty.

When it was established in 1930, the Institute aimed to provide, in the words of its founding Director Abraham Flexner, "a haven where scholars and scientists could regard the world and its phenomena as their laboratory without being carried off into the maelstrom of the immediate." Over the past eight decades, the Institute has held remarkably true to that vision, offering an environment where leading researchers from around the world can explore fundamental questions driven purely by their curiosity and imagination. The Members and former Members of the Institute form an increasingly interconnected and extended community of scholars that now numbers more than six thousand.

The program featuring the Schools of Mathematics and Natural Sciences will occur on Friday and Saturday, September 24 and 25, and will include seminars and lectures by current members of the Faculty, as well as by former Faculty John Milnor and Frank Wilczek. The Schools of Historical Studies and Social Science will hold their program on Friday and Saturday, November 12 and 13, and will present seminars and a lecture featuring current Faculty, as well as a panel discussion moderated by Institute Trustee Harold Shapiro.

All current and former Faculty and Members are welcome to attend both celebrations. It is hoped that many will return to join in these events and will remain engaged in the work of the Institute. To register and to view full program information, please visit www.ias.edu/news/80th. Questions may be addressed to ias80@ias.edu or Linda Geraci, AMIAS Liaison, at (609) 734-8259. ■

Jean Bourgain Wins 2010 Shaw Prize in Mathematics

Jean Bourgain, Professor in the School of Mathematics, has been awarded the 2010 Shaw Prize in Mathematics for his influential work in mathematical analysis and its application to partial differential equations, mathematical physics, combinatorics, number theory, ergodic theory, and theoretical computer science.

The Shaw Prize, which consists of three annual awards of $1 million each in Astronomy, Life Science and Medicine, and Mathematical Sciences, was established in 2002 by Sir Run Run Shaw, a Hong Kong film and television producer. The international award, administered through the Shaw Foundation, was created to honor individuals who have achieved significant breakthroughs in scientific research and whose work has resulted in a positive impact on mankind. The prizes will be presented at ceremonies in Hong Kong on September 28.

Peter Goddard, Director of the Institute, commented, "We are delighted that Bourgain's remarkable contributions across a wide area of mathematical analysis have been recognized by the Shaw Prize. His achievements in solving many important, difficult, and long-standing problems by introducing new mathematical techniques are unequalled today."

ANDREA KANE

Professor Jean Bourgain with Russell Impagliazzo, Visiting Professor in the School of Mathematics, at a workshop on pseudorandomness, one of the many areas of mathematics influenced by Bourgain's work

Bourgain's work touches on many central topics of mathematical analysis: the geometry of Banach spaces, harmonic analysis, ergodic theory, spectral problems, and nonlinear partial differential equations from mathematical physics and combinatorial number theory. His work solved longstanding problems in convexity theory and harmonic analysis, such as Mahler's conjecture and the lambda-p set problem. It also has had important consequences in theoretical computer science and on exponential sums in analytic number theory. In Hamiltonian dynamics, he developed the theory of invariant Gibbs measures and quasi-periodicity for the Schrödinger equation.

The recipient of the Fields Medal in 1994, Bourgain has received many other honors, including the Empain Prize (1983), the A. De Leeuw-Damry-Bourlart Prize (1985), the Langevin Prize (1985), the Elie Cartan Prize (1990), the Ostrowski Prize (1991), and the Vernadsky Gold Medal (2010). Bourgain is a Foreign Member of the French Academy of Sciences, the Polish Academy of Sciences, the Royal Swedish Academy of Sciences, and the Academia Europaea.

Bourgain received his Ph.D. in 1977 and his Habilitation in 1979, both from the Free University of Brussels. He was a Research Fellow at the National Fund for Scientific Research in Belgium before beginning his teaching career at the Free University of Brussels. He held Professorships at the University of Illinois and IHÉS (Institut des Hautes Études Scientifiques) before joining the Faculty of the Institute for Advanced Study in 1994.

David Spergel, who shares this year's Shaw Prize in Astronomy, is a former Member (1985–88) in the Institute's School of Natural Sciences. Spergel is currently Professor and Chair of the Department of Astrophysical Sciences at Princeton University.

Since the inauguration of the Shaw Prize in 2004, one or more of the recipients each year have been affiliated with the Institute. Faculty members who have received the prize include Peter Goldreich, Professor Emeritus in the School of Natural Sciences, who was awarded the prize in Astronomy in 2007, and Robert Langlands, Professor Emeritus in the School of Mathematics, who shared the Mathematics prize with Richard Taylor in 2007 (see articles, pages 1 and 5). In 2004, the late geometer Shiing-Shen Chern, former Member (1943–46, 1954–55, 1964–65) in the School of Mathematics, was recognized for his lifetime of achievement. Other former Members who have received the prize include: P. James Peebles (Astronomy, 2004); Andrew J. Wiles, who is also an Institute Trustee (Mathematics, 2005); David Mumford (Mathematics, 2006); Ludwig Faddeev (Mathematics, 2008); Frank Shu (Astronomy, 2009); and Simon Donaldson (Mathematics, 2009). ■

The Unity of Mathematics

Mathematics is part of the general scientific culture. We are contributing to a whole, organic collection of ideas, even if the part of mathematics which I'm doing now is not of direct relevance and usefulness to other people. If mathematics is an integrated body of thought, and every part is potentially useful to every other part, then we are all contributing to a common objective. If mathematics is to be thought of as fragmented specializations, all going off independently and justifying themselves, then it is very hard to argue why people should be paid to do this. We are not entertainers, like tennis players. The only justification is that it is a real contribution to human thought. Even if I'm not directly working in applied mathematics, I feel that I'm contributing to the sort of mathematics that can and will be useful for people who are interested in applying mathematics to other things.

—Michael Atiyah

Modern mathematics has become so extensive and so complex that it is essential, if mathematics is to stay as a whole and not become a pile of little bits of research, to provide a unification, which absorbs in some simple and general theories all the common substrata of the diverse branches of the science, suppressing what is not so useful and necessary, and leaving intact what is truly the specific detail of each big problem. . . . Very few persons are capable of grasping the entire forefront of science, of seizing not only the weak points of resistance, but also the part that is most important to take on, the art of massing the troops, of making each sector work toward the success of the others, etc.

—André Weil

We are not very pleased when we are forced to accept a mathematical truth by virtue of a complicated chain of formal conclusions and computations, which we traverse blindly, link by link, feeling our way by touch. We want first an overview of the aim and of the road; we want to understand the idea of the proof, the deeper context. . . . A modern mathematical proof is not very different from a modern machine, or a modern test setup: the simple fundamental principles are hidden and almost invisible under a mass of technical details.

—Hermann Weyl

structure of automorphic representations of different groups. The fundamental lemma, which has been described as a matching conjecture,[3] is a very precise conjecture used in the Selberg trace formula to prove some cases of the principle of functoriality. The principle of functoriality is a core conjecture of the Langlands program that seeks to establish symmetry between whole numbers and links automorphic representations of different groups through their *L*-groups. Using layman's terms, Peter Sarnak, Professor in the School of Mathematics, compares the fundamental lemma to a screwdriver, functoriality to opening a screw, and the Langlands program to the big machine working to reveal the underlying structure of automorphic forms.

Over the years, the fundamental lemma turned out to be incredibly difficult to prove in the general case, although progress was made in specific cases, through work done by Langlands, his students, and others at the Institute and elsewhere. For more than two decades, Langlands gave up on resolving the fundamental lemma and spent his time studying fields unrelated to the Langlands program, most recently lattice models of statistical physics and the attendant conformal invariance. "The fundamental lemma was a problem that I thought was easy and it turned out to be hard," says Langlands. "The impulse is to concentrate on the problem, and so you concentrate on it for years. You don't, for obvious reasons, have the confidence to think beyond it. You can say, 'Well, I'll just assume it and think beyond it.' But then every person you meet will say, 'But what if it isn't true?'"

Still, the resolution of the fundamental lemma was presumed in major works, such as the stabilization of the Arthur-Selberg trace formula. (The Arthur-Selberg trace formula itself was developed by James Arthur, a former Member and Trustee.) Last fall, thirty years after Langlands first introduced it, a proof of the fundamental lemma by Bao Châu Ngô, a Member in the School of Mathematics from 2006–10, was confirmed. (Financial support for Ngô's Membership in 2009–10 was provided by the Charles Simonyi Endowment and the Ambrose Monell Foundation.)

LOTTE MEITNER-GRAF, LONDON

PHOTOS OF WEIL AMD HARISH-CHANDRA: HERMAN LANDSHOFF/INSTITUTE FOR ADVANCED STUDY

In his conjectures, now collectively known as the Langlands program, Robert Langlands drew on the work of Hermann Weyl (left), André Weil (top, right), and Harish-Chandra (bottom, right), among others with extensive ties to the Institute.

Ngô's proof, based on a geometric interpretation of endoscopy theory, follows the work of many other mathematicians, including Mark Goresky, Thomas Hales, Hervé Michel Jacquet, Robert Kottwitz, Jean-Pierre Labesse, Gérard Laumon, Robert MacPherson, Jonathan Rogawski, Shelstad, Rainer Weissauer, and Jean-Loup Waldspurger. "It is very rare that you can take a proof in the geometric setting and convert it to the genuine number theoretic setting. That is what has transpired through Ngô's achievement," says Sarnak. "Ngô has provided a bridge, and now everybody is using this bridge. What he has done is deep. It is below the surface and it is understanding something truly fundamental. There are a number of theorems that, in the past, would have included the statement, 'Assume the fundamental lemma, then the following remarkable thing is true.' A number of theories—statements that were of great interest but weren't known to be true—are now known to be true."

In 1967, Langlands wrote a seventeen-page handwritten letter to André Weil, a Professor at the Institute at the time, in which he proposed a grand unifying theory that relates seemingly unrelated concepts in number theory, algebraic geometry, and the theory of automorphic forms. A typed copy of the letter,[4] made at Weil's request for easier reading, circulated widely among mathematicians in the late 1960s and 1970s, and for more than three decades, mathematicians have been working on its conjectures, known collectively as the Langlands program.

The Langlands program, of which endoscopy theory is a part, is incredibly vast and far-reaching and has many different manifestations. "It is one of the great insights into twentieth-century mathematics. It is a beautiful synthesis of the theory of numbers and symmetry—the theory of groups—specifically Lie groups, " says Sarnak. "It gives a vision of what you can do with a theory of groups in connection with number theory. It gives the boundaries of what you can hope to do, but it also shows what you can't do. This insight has created fruits in every direction, meaning people who work on some little aspect of it are forced to understand what they're doing better in order that other people can use it."

In addition to changing the field of automorphic forms drastically, making the infinite-dimensional representation theory of reductive groups into a major field of mathematical activity, and introducing a general class of *L*-functions that have had major consequences for algebraic number theory, Langlands's conjectures have had a significant influence on other fields, such as physics. In the geometric Langlands program, created by former Member Vladimir Drinfeld and collaborators, some of the ideas are converted from number theory into statements in geometry. The geometric form is particularly rich for implications in theoretical physics, especially string theory. In 2006, Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, cowrote a 225-page paper on the relation of part of the geometric Langlands program to ideas of the duality between electricity and magnetism.[5] During his time at the Institute, Ngô has been working on a program to bring the Arthur-Selberg trace formula into the framework of the geometric Langlands program.

The use of the trace formula to prove cases of functoriality requires combinatorial identities—the fundamental lemma—between orbital integrals. Orbital integrals and weighted orbital integrals are the basis of the local harmonic analysis and invariant harmonic analysis theories developed by the late Harish-Chandra, Professor in the School of Mathematics. "In crude terms, one side of the trace formula contains terms related to the characters of automorphic representations," observes Hales.[6] "The other side contains terms such as orbital integrals. Thanks to the trace formula, identities between orbital integrals on different groups imply identities between the representations of the two groups."

From early on, attempts to prove the fundamental lemma have involved geometric interpretations of the identities of orbital integrals—interpretations that have become increasingly sophisticated through the work of

The following mathematicians and physicists, mentioned in the accompanying articles about the fundamental lemma, are or have been affiliated with the Institute for Advanced Study as a Professor and/or Member. More information about their affiliations and dates of association may be found at www.ias.edu/people/cos.

James Arthur
Michael Atiyah
Bill Casselman
Pierre Deligne
Paul Dirac
Vladimir Drinfeld
Edward Frenkel
Mark Goresky
Thomas Hales
Harish-Chandra
Hervé Michel Jacquet
Robert Kottwitz
Jean-Pierre Labesse
Robert Langlands
Gérard Laumon
Robert MacPherson
Bao Châu Ngô
Jonathan Rogawski
Peter Sarnak
Atle Selberg
Diana Shelstad
Goro Shimura
André Weil
Rainer Weissauer
Hermann Weyl
Andrew Wiles
Edward Witten

Goresky, Kottwitz, Laumon, MacPherson, and Ngô.

Ngô's interest in the fundamental lemma[7] came in the late 1990s when he was writing his Ph.D. dissertation on a conjecture related to the fundamental lemma by Jacquet (who, with Langlands, proved the Jacquet-Langlands correspondence in 1970, providing one of the first examples of functoriality[8]). "Through my work on Jacquet's conjectures, I found a completely new method to tackle these kinds of problems to prove equalities," says Ngô. "I was quite tempted by Langlands's fundamental lemma but I was ill equipped. I needed to learn more of the mathematics and understand what it was about. I did not work on the lemma for maybe five or six years until I felt ready. In the meantime, other people were working on it. My own ideas were certainly not enough."

By 2004, Ngô was deeply invested in trying to solve the fundamental lemma. But he ran into a roadblock while trying to use the equivariant cohomology approach, which provides essential insight into the topological nature of the lemma, introduced by Goresky, Kottwitz, and MacPherson, Hermann Weyl Professor in the School of Mathematics. "I went into quite a despair. I had spent three years working on every possible angle," says Ngô. "I still believed the problem I set for myself was a good one. But I was missing one step." In 2006,

An often successful strategy, even though slow and usually inglorious, for breaching an otherwise unassailable mathematical problem is to reduce some aspect of it to a concrete, accessible form on which at least small inroads can be made and some experience acquired.

—Robert Langlands

during a three-month visit to the Institute, where he conducted a seminar on the fundamental lemma, Ngô asked Goresky about a statement concerning perverse sheaves, which is unrelated to the fundamental lemma but provided insight for Ngô. "He explained to me one example that he and MacPherson knew where it could be proved," says Ngô. "It was the missing piece of my puzzle. Everything fit together. Still, it was not an easy process. There were a lot of details that had to be worked out very carefully." By spring 2007, Ngô was convinced that his proof worked. He returned to the Institute in fall 2007 and ran another seminar about the fundamental lemma, during which his proof was scrutinized by Pierre Deligne, Professor Emeritus in the School of Mathematics, and others. His paper went through six different versions before it was made available online in 2008, and recently published.[9]

It was Waldspurger's work that suggested that the proof of the fundamental lemma could be arrived at in the geometric setting, which allows deformations, in contrast to number theory, which does not. Transfer factors, wherein orbital integrals on one group are multiplied in order to be orbital integrals on the other, are necessary to transport automorphic forms. A transfer conjecture was formulated initially by Langlands and Shelstad, then later by Kottwitz and Shelstad in a more flexible and twisted form. In the mid 1990s, Waldspurger proved that the transfer conjecture would follow from the corresponding fundamental lemma.

"This was quite a surprise," notes Arthur.[10] "For the fundamental lemma pertains to very special functions at certain *p*-adic places, while the transfer conjecture applies to general functions at all *p*-adic places. Waldspurger used global methods, specifically a simple version of the trace formula, to solve what was a local problem." Shelstad had already solved the transfer problem for archimedian places, using Harish-Chandra's work, which served as a guide for the construction of general transfer factors. In the past few years, Waldspurger also completed a far-reaching study in harmonic analysis, which among other things reduces the transfer conjecture of Kottwitz and Shelstad to a form of the fundamental lemma.

In his proof of the fundamental lemma, Ngô exploited the interplay of local and global methods in "ingenious ways," according to Arthur, and "observed that the entire geometric side could be expressed as a sum over the rational points of an arithmetic Hitchin fibration, the arithmetic analogue of a variety familiar from the theory of G-bundles on a Riemann surface."

Important arithmetic applications follow from endoscopy theory, including the transfer of automorphic representations from classical groups to linear groups and the construction of Galois representations attached to automorphic forms via Shimura varieties (developed by Goro Shimura, a frequent Member at the Institute). Shimura varieties are a central part of Langlands's program, both as a source of representations of Galois groups and as tests for the conjecture that all motivic *L*-functions are automorphic.[11] In addition to being critical to the comparison of trace formulas that is part of the theory of endoscopy, the fundamental lemma is essential in the comparison of the automorphic Arthur-Selberg trace formula and the geometric Grothendieck-Lefschetz trace formula needed to establish reciprocity laws for Shimura varieties.

With the proof of the fundamental lemma, Langlands is thinking again about how the stabilized trace formula might be used to establish the basic conjectures he outlined in 1967. "Until recently, I didn't have any idea how one could attack these basic conjectures in a genuinely promising fashion," says Langlands. "But thinking about the proof of the fundamental lemma and the techniques it provides, I shouldn't say I'm optimistic, but I really think there is something there on which one can get a handle."

About six years ago, when he heard of the progress being made with the fundamental lemma, Langlands began working in an area he calls "beyond endoscopy." Primary among Langlands's interests is using the Arthur-Selberg trace formula to resolve the principle of

(Continued on page 11)

SPECIAL PROGRAM 2010–11

Galois Representations and Automorphic Forms

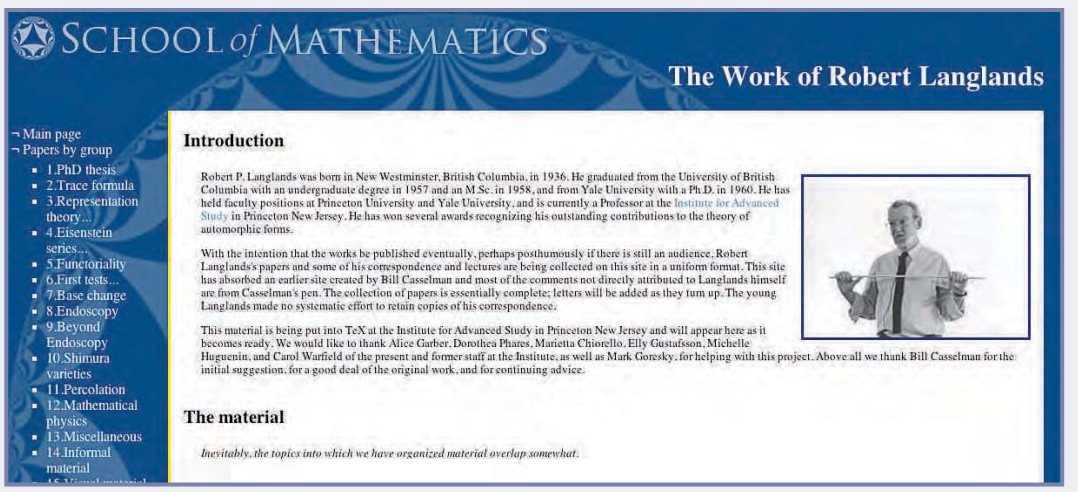
During the 2010–11 academic year, Richard Taylor of Harvard University will be the Distinguished Visiting Professor in the School of Mathematics. He will lead a program on Galois representations and automorphic forms.

The program will embrace all aspects of the conjectural relationship between automorphic forms and Galois representations: functoriality and Langlands's conjectures, analytic approaches (in particular the trace formula), algebraic approaches (those growing out of Wiles's work on Fermat's Last Theorem), *p*-adic Hodge theory (the so called *p*-adic Langlands program) and applications to other problems in number theory.

There will be a weekly seminar and a week-long workshop during the week of March 21, 2011, highlighting recent developments connected with the program.

Modern Mathematics and the Langlands Program

It has been said that the goals of modern mathematics are reconstruction and development.[1] The unifying conjectures between number theory and representation theory that Robert Langlands, Professor Emeritus in the School of Mathematics, articulated in a letter to André Weil in 1967, continue a tradition at the Institute of advancing mathematical knowledge through the identification of problems central to the understanding of active areas or likely to become central in the future.



Robert Langlands's papers and some of his correspondence and lectures are available at http://publications.ias.edu/rpl.

"Two striking qualities of mathematical concepts regarded as central are that they are simultaneously pregnant with possibilities for their own development and, so far as we can judge from a history of two and a half millennia, of permanent validity," says Langlands. "In comparison with biology, above all with the theory of evolution, a fusion of biology and history, or with physics and its two enigmas, quantum theory and relativity theory, mathematics contributes only modestly to the intellectual architecture of mankind, but its central contributions have been lasting, one does not supersede another, it enlarges it."[2]

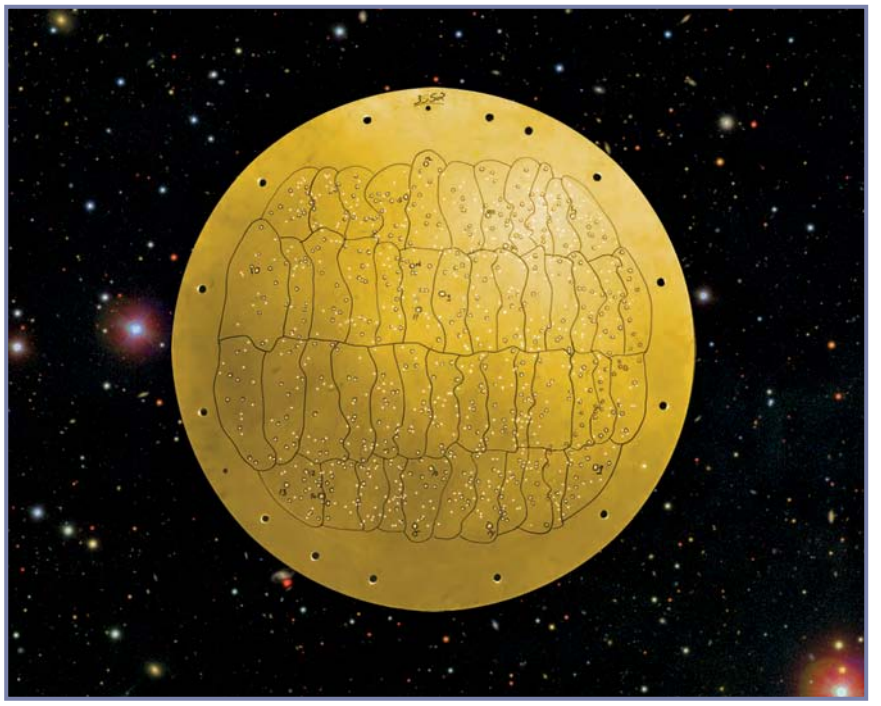
In his conjectures, now collectively known as the Langlands program, Langlands drew on the work of Harish-Chandra, Atle Selberg, Goro Shimura, André Weil, and Hermann Weyl, among others with extensive ties to the Institute.

Weyl, whose appointment to the Institute's Faculty in 1933 followed those of Albert Einstein and Oswald Veblen, was a strong believer in the overall unity of mathematics, across disciplines and generations. Weyl had a major impact on the progress of the entire field of mathematics, as well as physics, where he was equally comfortable. His work spanned topology, differential geometry, Lie groups, representation theory, harmonic analysis, and analytic number theory, and extended into physics, including relativity, electromagnetism, and quantum

(Continued on page 7)

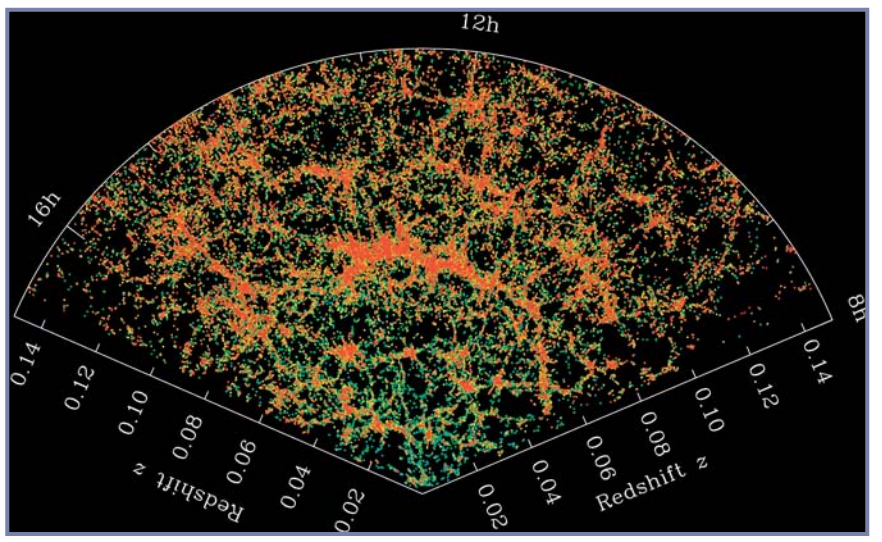
observations were—finally—well underway. My concentration during that year was developing theoretical modeling and statistical analysis techniques, which we later applied to SDSS maps of cosmic structure to infer the clustering of invisible dark matter from the observable clustering of galaxies. By the time I returned for a one-term visit in 2006, the project had entered a new phase known as SDSS-II, and I had become the spokesperson of a collaboration that encompassed more than three hundred scientists at twenty-five institutions around the globe. With SDSS-II scheduled to complete its observations in mid-2008, I joined a seven-person committee that spent countless hours on the telephone that fall, sorting through many ideas suggested by the collaboration and putting together the program that became SDSS-III.

The SDSS uses a dedicated telescope (located in New Mexico) with a 2.5-meter-diameter mirror, similar in size to the Hubble Space Telescope's, but much smaller than those of the largest ground-based telescopes (whose mirrors are eight to ten meters across). What makes the SDSS special are the exceptionally powerful instruments on the *back* of the telescope. The first is a giant digital camera—the largest in the world at the time it was built—which has taken deep, multicolor images that cover more than half the northern-hemisphere sky, detecting over 100 million galaxies and 200 million stars. But to measure the distance to a galaxy or the velocity and chemical composition of a star, one has to disperse its light through a prism and identify the fine features etched on its spectrum by individual species of atoms, a kind of observation that astronomers have traditionally done one object at a time. The SDSS took this three-dimensional mapping into mass production by feeding its spectrographs with 640 optical fibers, plugged into 640 precision-drilled holes on a thirty-inch aluminum plate, each hole admitting the light from a single preselected galaxy, star, or quasar. After eight years of operations and more than 2,600 plates, SDSS I and II had measured spectra of nearly one million galaxies, more than one hundred thousand quasars, and half a million stars.



D. SCHLEGEL/SDSS-III

An SDSS-III plugplate, which admits light from preselected galaxies, stars, and quasars, superposed on an SDSS sky image



M. BLANTON/SDSS

Each dot on this slice through an SDSS map represents a galaxy, which is typically made up of about 100 billion stars. Blue dots mark younger and red dots mark older galaxies. The earth is located at the vertex of the slice—the most distant galaxies in this map are 2 billion light years away from it.

The largest of the SDSS-III surveys (known as BOSS, the Baryon Oscillation Spectroscopic Survey) is aimed at the biggest mystery of contemporary cosmology: the accelerating expansion of the universe. While cosmic expansion was discovered eighty years ago by Edwin Hubble, it had generally been assumed that the expansion would slow down over time because of the gravitational attraction of matter in the universe. In the late 1990s, however, astronomers studying distant supernova explosions found that the expansion of the universe has been speeding up for the last five billion years. Either the universe is pervaded by an exotic form of energy that exerts repulsive gravity—perhaps the "vacuum energy" produced by quantum mechanical fluctuations in otherwise empty space—or else our prevailing theory of gravity itself breaks down on cosmological scales, maybe because gravity "leaks" into extra spatial dimensions that are hidden from our everyday experience.

BOSS will test the "vacuum energy" hypothesis with unprecedented precision, using a novel method that relies on a subtle feature in the clustering of galaxies and intergalactic matter. This feature, the imprint of "baryon acoustic oscillations" in the early universe, has a known physical scale, and after measuring its apparent size (e.g., as an angle on the sky) one can use simple trigonometry to infer the distances to objects that are billions of light years away. Precise determinations—accurate to 1 percent or better—require measuring cosmic structure over enormous volumes, which BOSS will do by mapping the spatial distribution of 1.5 million luminous galaxies and of absorbing gas along the lines of sight to 150,000 distant quasars. BOSS observes fainter objects than the original SDSS, so it required major upgrades to the spectrographs—more sensitive detectors, more efficient optical elements, 1,000 fibers instead of 640—which were installed and commissioned in fall 2009. The survey is now running full tilt and producing its first scientific results. However, the system is very complex, so a typical week still brings a software glitch or hardware problem that generates a cascade of email traffic and telecon discussion, and in rare cases an emergency trip to New Mexico by one of the instrument experts.

Closer to home, two SDSS-III surveys will map the structure and formation history of our own galaxy, the Milky Way. SEGUE-2 (whose acronymic history is too complicated to recount here) focuses on the outer galaxy, which observations and theory suggest was built largely via acts of galactic cannibalism, with the gravity of the Milky Way stretching and eventually destroying infalling satellite galaxies. The SEGUE maps (from SDSS-II and SDSS-III combined) contain about 350,000 stars, revealing partly digested strands of these galactic progenitors. The stellar motions measured by SEGUE also probe the mass and shape of the dark matter "halo" whose gravity holds the Milky Way together.

The inner galaxy is hidden from our view by interstellar dust, tiny smokelike particles that float between the stars and block visible light. APOGEE (the Apache Point Observatory Galactic Evolution Experiment) will map the inner galaxy using an innovative spectrograph that measures infrared light, which passes through interstellar dust nearly unscathed. With the exception of hydrogen, helium, and lithium, all atoms in the universe were forged in stars, then dispersed to the surrounding gas when the stars died. APOGEE spectra will allow separate measurements of a dozen chemical elements—carbon, oxygen, silicon, sulfur, iron, titanium, etc.—for each of the 100,000 stars that it observes. Because different elements form via different nuclear pathways in different kinds of stars, each of APOGEE's chemical "fingerprints" will encode information not just about the star being measured but about all of the preceding stars that contributed to its composition.

One of the biggest developments in astronomy over the last fifteen years has been the discovery of planets outside the solar system, most of them found via the slight wobble they induce as they orbit their parent stars. Many of the planetary systems discovered to date are very different from our own, with massive, Jupiter-like planets that loop around their parent stars in months or even days, often following elongated elliptical paths rather than the nearly circular orbits that prevail in the solar system. These oddities suggest that many planets "migrate" after birth or undergo chaotic gravitational battles with their siblings. The Sloan survey will, in characteristic fashion, attack this problem with large numbers, monitoring a total of 10,000 stars using a novel, fiber-fed instrument that can measure tiny motions (as small as a few meters per second) of sixty stars at a time. MARVELS (the Multi-object APO Radial Velocity Large-area Survey) hopes to detect between one and two hundred Jupiter-like planets in close orbits, allowing quantitative statistical tests of theories of planet formation and discovering rare systems that may reveal crucial short-lived phases in planetary evolution.

The Institute for Advanced Study helped start the SDSS with a critically timed financial contribution, but over the lifetime of the project its most important contributions have been human ones. Many Institute Members have done spectacular science with SDSS data over the years, and today four of the dozen scientists on the top-level SDSS-III management committee are former IAS postdocs. This is a remarkable statistic for a small institution focused largely on theoretical research. It speaks to the close interaction between theorists and observers in contemporary astronomy—with many individuals who straddle what was once a clear line of demarcation—and equally to the success of the Institute in inspiring its Members to pursue ambitious lines of research whose payoff may lie many years in the future. ■

David H. Weinberg is Professor of Astronomy and Distinguished Professor of Mathematical and Physical Sciences at Ohio State University. He was an AMIAS-supported Member in the School of Natural Sciences during the 2009–10 academic year and was a Member in the School in 1992–94, 2001–02, and 2006. He is the Project Scientist of SDSS-III.

Asteroids as the Next Stepping Stones

BY PIET HUT

In April, President Obama laid out an interesting new vision for human exploration of the solar system, more exciting that anything that has been proposed in the last forty years. A key component of his vision is the proposal to send humans to asteroids, first, well before sending them to Mars, while skipping the moon as a destination.

During the first thirty years after the last moon landing, in 1972, human space flight has been rather boring, frankly. The shuttle was built mainly to reach the International Space Station, while that Space Station was built mainly to give the shuttle something to fly to. It all happened a few hundred miles above the surface of Earth, in stark contrast with the short era of only three years, 1969–72, in which there were travelers who really left Earth to visit another body, the moon.

ANDREA KANE

Piet Hut (center), who heads the Institute's Program in Interdisciplinary Studies, has long advocated the idea of astronauts visiting an asteroid and protecting Earth from asteroid impacts.

Whether it is worth the money and effort to explore the solar system by sending humans out to places other than the near-Earth environment is a matter of debate. Scientifically, one can make a case for money being better spent through robotic on-site exploration and telescopic remote observations. But human space flight is not primarily about science. It is the direct extension of many centuries of exploration, and as such it seems worth the effort. For one thing it is exciting in itself, and for another, we won't know what its advantages will be, in the long run, unless we give it a try.

Back in 2003, President Bush finally presented a forward-looking vision for human space flight that would leave low Earth orbit. However, the main goal was a return to the moon, mainly to redo what had been done already decades earlier. What makes Obama's vision much more interesting is it requires a jump that is just a little further than what is required to reach the moon, but far less of a jump than what is needed to reach Mars. Instead of reaching for one of the two closest planets to Earth, the idea is to visit one of the hundreds of thousands of asteroids that come far closer to Earth than another planet ever does.

In fact, some of the asteroids sometimes come very close to Earth, too close for comfort. The most dramatic documented historical impact was the one that took place sixty-five million years ago, creating a more than one-hundred-mile-wide crater that is now buried deep under the surface in the Yucatan Peninsula. It was this impact that caused the demise of the dinosaurs, as well as a significant fraction of all species present on Earth at that time. Clearly, it is in our interest to not go the way of the dinosaurs ourselves, and to keep an eye out for future encounters of that kind.

The *a priori* chance for Earth to be hit by a ten-kilometer-diameter asteroid, like the one that hit Mexico at the end of the Cretaceous period, at any given time is rather small. And thanks to an intense observational campaign during the last few decades, we now know that the chance will be significantly smaller than statistically expected, at least during the next few centuries. The reason is that we have mapped most of the large asteroids with orbits crossing the orbit of Earth, and the good news is that none of those floating mountains are currently on a collision course with our home planet.

However, the bad news is that there are hundreds of thousands of smaller asteroids in our vicinity, each more than one hundred meters in diameter, and they can still cause enormous destruction on a local scale, were one of them to hit Earth. While most of those have not yet been discovered, an active observational program is being developed with the goal of charting them all, or at least a large majority of them. We don't know what that program will teach us: whether all asteroids that we find will miss us, or whether there will be one or more that are headed for us in the foreseeable future.

If and when observations show us that a small asteroid is on its way to hit Earth, the challenge will be to try to deflect it before it reaches us. Rather than waiting for such an asteroid to be discovered, it would be far more prudent to be proactive, to explore asteroids in some detail, to characterize their nature and composition and their physical properties in general.

It will be so much more interesting to watch astronauts hop around in the very low gravity of an asteroid, as a tiny world in itself, compared with going back once again to the moon. And it will give us more information about the kind of impact danger that is permanently lurking out there for us, small but not negligibly so. ■

Professor Piet Hut, who heads the Institute's Program in Interdisciplinary Studies, has been active in promoting the protection of Earth from asteroid impacts since he started the B612 Foundation (www.b612foundation.org) in 2002, together with another astrophysicist and two astronauts. He has long advocated the idea of astronauts visiting an asteroid, including in a 2003 piece that appeared in a publication to honor the astronauts who died in the crash of the Space Shuttle Columbia (see www.edge.org/3rd_culture/columbia/columbia.html#hut).

MODERN MATHEMATICS *(Continued from page 5)*

mechanics. "For [Weyl] the best of the past was not forgotten," notes Michael Atiyah, a former Institute Professor and Member, "but was subsumed and refined by the mathematics of the present."[3]

Geometry and analysis were central to Weyl's interests, and his inclination to organize and synthesize drew him to the theory of groups and their representations, also known as symmetry. Weyl brought representation theory into quantum mechanics, leading the way for modern physicists to think of unexpected regularities in terms of underlying symmetry groups.

With much help from Weyl, Lie groups and Lie algebras became central to mathematics and theoretical physics. Under the combined influences of relativity theory and quantum mechanics, the study of infinite-dimensional representations of Lie groups was transformed into a major field in contemporary mathematics by Harish-Chandra. Harish-Chandra first came to the Institute in 1947–48 as an assistant to the theoretical physicist Paul Dirac, who wrote one of the first papers on infinite dimensional irreducible representations. Harish-Chandra ultimately abandoned physics to study representation theory and harmonic analysis of semisimple Lie groups.

Langlands's early work in representation theory involved adapting the methods of Harish-Chandra to the theory of automorphic forms. Endoscopy, which aims to distinguish the internal structure of automorphic representations of different groups, arose from Langlands's study of the zeta functions of Shimura varieties developed by Goro Shimura and in the theory of the discrete series, a theory created by Harish-Chandra at the Institute in the sixties. The modern theory of Shimura varieties, so named by Langlands in the 1970s, began with the development of the theory of abelian varieties with complex multiplication by Shimura, Yutaka Taniyama, and Weil in the mid-1950s.

Langlands's principle of functoriality, which uses the Selberg trace formula and the fundamental lemma to link automorphic representations of different groups through their *L*-groups, was informed by the theory of class fields, and the representation theory of semisimple Lie groups in the form given to it by Harish-Chandra.

Much of the modern theory of automorphic forms is governed by two fundamental problems that are at the heart of the Langlands program: Langlands's principle of functoriality and the general analogue of the Shimura-Taniyama-Weil conjecture on modular elliptic curves. The work of Andrew Wiles that led to a proof of Fermat's Last Theorem suggests that the two problems, among the deepest questions in mathematics, are inextricably linked.[4]

"Weyl was the father of the theory of representations of Lie groups, and Harish-Chandra was one of the great champions of the subject before Langlands came along," says Peter Sarnak, Professor in the School of Mathematics. "The theory of representations comes up in physics. It comes up in algebra. Langlands's insight was its role in number theory."

The breadth and scope of Langlands's mathematical vision, from the trace formula, functoriality, and endoscopy to representation theory and Shimura varieties, can be explored through his papers and some of his correspondence and lectures, which are posted at http://publications.ias.edu/rpl/. The materials provide a sense of the historical context, precedents, and explorations that led to the recent proof of the fundamental lemma. They also articulate Langlands's view of the problems still in need of attention and suggest directions for unifying distant concepts and finding new connections between apparently unrelated subjects. ■

1 "On A. Weil," by Yutaka Taniyama, *Bulletin of the American Mathematical Society* 46, no. 4 (October 2009), 667–68

2 "Is There Beauty in Mathematical Theories?" lecture delivered by Robert P. Langlands, University of Notre Dame, January 2010, http://publications.ias.edu/rpl_works/L12/beauty/ND.pdf

3 "Hermann Weyl, November 9, 1885–December 9, 1955," by Michael Atiyah, *Biographical Memoirs* 82, (National Academies Press, 2003), www.nap.edu/readingroom.php?book=biomems&page=hweyl.html

4 Preface by James Arthur, David Ellwood, Robert Kottwitz in *Harmonic Analysis, the Trace Formula, and Shimura Varieties*, Clay Mathematics Proceedings 4 (2005), 265–66, www.claymath.org/library/proceedings/cmip04.pdf

Bethlehem: American Utopia, American Tragedy

BY SETH MOGLEN

ANDREA KANE

Seth Moglen, Friends of the Institute for Advanced Study Member in the School of Social Science, presents his research on Bethlehem, Pennsylvania, at a seminar series organized by Joan Wallach Scott (far left), Harold F. Linder Professor in the School.

Members of the Dewey Seminar in the School of Social Science are working on a range of issues, but all of our inquiries have led back in one way or another to the problem of democracy and education. I am interested specifically in the question of what truly democratic research universities might look like in the twenty-first century. My own work in this area is based on an experiment in university–community collaboration that I codirect at Lehigh University, a midsized private research university located in Bethlehem, Pennsylvania.

Bethlehem was founded in 1741 as a utopian religious community by the Moravians, a pietist, central European Protestant sect. The Moravians created a communal economy, in which everyone worked for the community and received on equal terms not only food, shelter, and clothing, but also access to free education, childcare, healthcare, and care for the elderly. There was an exceptional level of gender symmetry and racial integration in Moravian Bethlehem. Women had been freed from the burden of privatized childcare and domestic labor so that they could assume spiritual and social leadership roles. Africans, Native Americans, and Europeans speaking at least sixteen languages lived, worked, worshipped, and learned together. Everyone was taught to read. In contrast to the usual story of failed utopias, the community was economically successful and technologically advanced.

The egalitarianism of this community was, however, compromised in emblematically American ways from the outset. Most of the Africans, living in conditions of material equality with their European co-religionists, were also held as chattel by the church. The town was built on land that had been stolen from the native people, the Lenape, in an especially cynical manner. And despite its prosperity, the communal economy was dismantled after one generation by church leaders in Germany. The ensuing privatization of social and economic life led swiftly to the collapse of both economic and gender equality.

A hundred years later, in the late nineteenth century, Bethlehem became one of the iconic steel towns of industrial America. It was home to Bethlehem Steel, one of the world's largest steel companies and one of the wealthiest corporations in American history. Bethlehem Steel played an important role in the development of structural steel, most famously the I-beam, which made possible the skyscrapers, suspension bridges, and battleships of the twentieth century.

For a century, every aspect of life in the city revolved around the massive Bethlehem Steel plant. Virtually every family in the city owed its livelihood, directly or indirectly, to "the Steel." It created extraordinary wealth for its owners and for its large managerial class: at midcentury, many of the wealthiest Americans were Bethlehem Steel executives—and they built their mansions on the north side of the city. The Steel also created livelihoods for thousands of working-class immigrants from many nations, who poured into South Bethlehem to work in the plant. These immigrants built tight-knit, intergenerationally sustained ethnic neighborhoods. Some people today are still living in the houses they were born in eighty or ninety years ago.

In the late nineteenth and early twentieth centuries, there was intense economic exploitation in Bethlehem. Many steel workers were maimed or killed on the job, and they worked long hours for low wages. There was, in response, a long history of labor organizing at the Steel—and of fierce anti-union violence. The Steel was finally unionized in 1941, on the eve of America's entrance into World War II, in the wake of an especially violent strike and the subsequent intervention of the Roosevelt administration. As a result of workers' successful organization, there were, for fifty years, good union jobs at the Steel, which brought higher wages, improved safety, paid vacations, good healthcare plans, and pensions. The union transformed Bethlehem into a model of postwar working-class prosperity.

Starting in the late 1970s, the U.S. steel industry underwent an intensifying crisis, as a result of rising competition from international steel producers and from non-union domestic "mini-mills." This crisis resulted in the gradual scaling back and ultimate closure of the steel plant in Bethlehem in 1995. In 2001, the Bethlehem Steel Corporation went bankrupt. It pursued a bankruptcy strategy that has become the norm for major American corporations: the company's lawyers persuaded the courts to allow them to sell off assets to other companies while "shedding" pension and health plans for retirees. As a result, thousands of former Bethlehem Steel employees lost the retirement and medical security for which they had given lifetimes of work.

Universities in our time can function as engines of democracy. They can foster the production, preservation, and dissemination of knowledge about the most urgent problems we face, locally as well as globally.

Today, more than a quarter of South Side residents live in poverty. South Bethlehem suffers from many related social problems, including failing public schools and serious public health challenges. The former Bethlehem Steel site is the largest urban brownfield in the United States. Its massive ruins and tainted soil cover more than a hundred acres at the heart of the city.

Lehigh University is located in the middle of South Bethlehem. Founded in the 1860s, Lehigh's early development was closely tied to Bethlehem Steel. It produced both the engineers and technical knowledge that made Bethlehem Steel one of the most profitable steel producers in the world. In turn, the company gave the university large sums of money, from its founding gift onward. Steel executives played a dominant role on the Board of Trustees from the university's founding until late in the twentieth century. The building of an elite, private research university also played an important symbolic role for the Steel's managerial class, as a way of accumulating and displaying cultural capital. Yet Lehigh largely closed its doors to the working people of South Bethlehem, who rarely had the financial or educational resources to gain admission. These dynamics led to entrenched patterns of town–gown class segregation that are common in university towns and cities across the country.

An important episode in university–community relations began in the 1960s, as Lehigh expanded its campus. Like many other private, urban universities (the University of Chicago is a parallel case, as Danielle Allen, UPS Foundation Professor in the School of Social Science, has shown), Lehigh worked closely with the city government to employ eminent domain powers in the name of "urban renewal." The city declared portions of an adjacent working-class neighborhood "blighted," seized whole blocks of houses, and sold them to the university, which razed the homes and built new sections of its campus where its neighbors had been living.

Over the last twenty years, Lehigh has taken steps to develop more positive relations with its urban neighbors, pursuing strategies similar to those employed by other private universities. These well-intentioned efforts have produced some positive results, but they have been haunted by the histories of segregation they have sought to address, and they have been weakened by inadequate attention to persistent, underlying power relations. Like other wealthy universities, Lehigh has tended to oscillate between viewing its poorer neighbors as a potential danger to be policed or as beneficiaries of charity. Rarely has it been able to recognize its neighbors as partners in education and democracy.

This was the state of affairs in 2004, when the city of Bethlehem arrived at a momentous turning point. After a decade of abandonment, the Steel site was purchased in 2004 by a New York–based real-estate conglomerate. The major stakeholder proved to be the Las Vegas Sands corporation, which successfully acquired a license to open a casino in the middle of the brownfield. (The state of Pennsylvania had just legalized casino gambling as a strategy for postindustrial urban and regional redevelopment.) Competing positive and negative claims about the project circulated. City officials and Sands executives asserted that the casino would generate tax revenue, would create jobs, had the resources to develop the site, and would foster urban redevelopment. Critics asserted that the casino would bring crime and prostitution; that the city would be overrun by traffic; that it would create urban blight and the collapse of retail districts and neighborhoods, including those a few blocks from Lehigh's campus. Bethlehem residents had mixed responses: some were hopeful, others terrified. But there was, at least in my experience, a virtually universal sense of powerlessness: people felt that they would have no role in making decisions about the future of the Steel site, around which their lives had revolved for generations, or about the future of the city more generally.

It was in this context, three years ago, that we launched the South Side Initiative (SSI). A group of Lehigh faculty (mostly in the humanities and social sciences, but some from the natural sciences, business, education, and engineering) began to meet with community leaders and residents in order to understand what role the university might play at this moment of extraordinary change in the city. In response to what we learned, SSI developed a range of activities and programs. These were, in many respects, familiar to the usual functioning of a university. We brought in visiting speakers, held public events (forums, conferences, film series, public art projects), organized classes, and set up ongoing working groups. All of these activities, though, focused on topics of pressing concern in the city, and

(Continued on page 9)

DEWEY SEMINAR *(Continued from page 1)*

philosophers, sociologists, political scientists, literary critics, pedagogical experts, anthropologists, and historians working on various aspects of education. We met as our own group every other week to present our works-in-progress to each other.

For my part, I confessed to the group, early and often, that I was a newcomer to the education topic. Last September, I was much more acquainted with the literatures on income inequality, racial exclusion, and gender-sensitive approaches to justice. As I settled into my office, I got started on my current project: a philosophical analysis of a recent school-finance case, *Campaign for Fiscal Equity v. State of New York*. In this case, low-income plaintiffs from New York City successfully sued the state of New York for failing to provide an adequate kindergarten through twelfth-grade education, as guaranteed to them under the state constitution. My hunch is that we political theorists can learn a lot of valuable lessons from this case, insofar as it gives us an opportunity to study exactly how disputes over justice and equality in the distribution of public educational resources are being worked out in the courts. (John J. Kerr Jr., a member of the IAS Friends' Executive Committee, is a Partner at Simpson Thacher; his law firm provided invaluable pro-bono legal services for the low-income children who brought their complaint before the state court.)

Having very little background on education issues at the outset, I immersed myself in my colleagues' work. In our work-in-progress meetings, we discussed a Member's study on the barriers to graduation at community colleges; the value of approaches oriented toward creative, dialogical, and "higher-order" thinking for teaching children about science; the strengths and weaknesses of the federal No Child Left Behind approach to pupil performance and accountability; the surprising results from a Member's study on parental involvement in the day-to-day learning experiences of low-income pupils; or the advantages and disadvantages of granting elected local school boards substantial control over education-policy decision-making. As a participant in our theme Members' sessions, I navigated an especially steep learning curve, but my colleagues encouraged my emerging arguments and ideas with unflagging generosity and good humor.

In the second ring of the Dewey Seminar, Danielle and Rob brought a handful of the Members working on the education theme together with outside participants in a three-stage anthology project. Participants in the anthology project from outside the Institute included school-finance economists; a law professor and an education professor specializing in religious accommodation in schools; political philosophers working on theories of democracy, equality, and the right to education; a leading policy expert from a prominent think tank; and a director of an education research institute. We met at the Institute on three occasions over the course of twelve months. At each one-week workshop, we presented our works-in-progress to each other. The project's format gave each of us an opportunity to solicit in-depth commentaries on our chapter drafts from specialists coming from diverse disciplinary perspectives. Our goal is to produce an interdisciplinary and agenda-setting scholarly book on education, under Danielle and Rob's joint editorship.

In the Dewey Seminar's third ring, as it were, Danielle and Rob brought a full slate of leading practitioners to the Institute campus to make presentations to the Members working on the education theme. These visitors range from district superintendents and college presidents to leading intellectuals at cutting-edge think tanks, classroom technology entrepreneurs, charter-school founders and teachers, a legal advocate and a judge deeply involved in the state school-finance cases, and senior figures from major philanthropic foundations that are operating significant grant programs in cooperation with various public school systems.

One visitor invited a group of Members to New York City to spend a day in the classroom with immigrant children learning to speak, read, and write the English language. To say our visit was an eye-opening experience would be a vast understatement. Then we took to the road a second time. Seth Moglen, a Member in the education theme group, led us on a tour of the multifaceted South Side Initiative—a community partnership involving Lehigh University and the residents of Bethlehem, Pennsylvania (see article, page 8).

From our exchanges with these practitioners, and from our impromptu "road trips," we learned a great deal about what is working, and, just as importantly, what is not working in our public schools today.

From our exchanges with these dynamic, engaged, and diverse practitioners, and from our impromptu "road trips," we learned a great deal about what is working, and, just as importantly, what is not working in our public schools today. By the end, I felt like I had been brought so close to the major policy action on the state and federal levels that I could anticipate the education headline stories of the week featured in National Public Radio broadcasts or the front pages of the *New York Times*.

As the year draws to a close, it is difficult for me to provide an adequate portrayal of my experience as a participant in the Dewey Seminar. With the generous support of the Institute, I have rubbed elbows with social scientists who know how our current education policies actually work and practitioners who breathe life into our abstract ideals on the ground. It is one thing to study the philosophy of education in the company of fellow storytellers; it is quite another to teach a special-education class or to organize a groundbreaking professional development course for eighth-grade biology teachers. I will be integrating the extraordinarily rich and inspirational lessons that I have learned in the Dewey Seminar into my own research activities and university teaching for years to come. ■

Anna Marie Smith, a Professor in the Department of Government at Cornell University, was the 2009–10 Rosanna and Charles Jaffin Founders' Circle Member in the School of Social Science. *Financial support for the Dewey Seminar was provided by the Spencer Foundation and the Ford Foundation.*

BETHLEHEM *(Continued from page 8)*

each was organized to foster opportunities for faculty and students to come together with community members to exchange different forms of knowledge and to deliberate on local challenges.

We brought in leading scholars, for example, who could share the results of their research about the actual effects of casino development in towns and cities elsewhere in the United States. At these well-attended public events, community members as well as faculty and students exchanged questions and concerns with public officials and visiting experts. Local journalists reported on the dialogue and on pressing policy issues such as real-estate speculation, protection of local business, and hiring practices at the casino. This last issue became especially salient when African American and Latino community members emphasized their experience with racialized hiring practices that have resulted in casinos in other cities hiring mainly white and often nonlocal staff, especially in better-paid casino floor positions. In response, SSI collaborated with a local economic development group to sponsor a series of public information sessions about jobs at the casino. We wanted these sessions to demystify the security screening process, which research has shown to be the main mechanism for reducing minority job applications. The sessions were conducted bilingually to accommodate Bethlehem's large Spanish-speaking immigrant population, and they were attended by hundreds of South Side residents. Through the sharing of scholarly expertise and local knowledge, SSI was thus able to collaborate with a local nonprofit to maximize opportunities for local employment.

Over the last three years, SSI has offered dozens of courses across the humanities, social sciences, and natural sciences focused on the city of Bethlehem—some of them team-taught by Lehigh faculty and community partners. Thousands of people at Lehigh and across the city have participated in our public forums, conferences, classes, and other events. Lehigh faculty and students are collaborating with community members to produce research on issues from economic development to environmental justice to public history. Cultivating processes of intellectual desegregation, we seek to expand the public sphere in the city, enabling people of all kinds to share knowledge and to invent democratic practices to meet our common needs.

Universities in our time can function as engines of democracy. This is not a casual observation. Even as democracy remains a foundational value in our society, we live at a moment of widespread pessimism about its effective, meaningful practice in the United States. As low voter turnout suggests, faith in the electoral process is disturbingly low. And even as ordinary people doubt their ability to influence Congress or state legislatures or city councils, most Americans have little experience actively deliberating and participating in collective decision-making about issues that immediately affect them, where they live or work or learn.

A generation ago, the cultural critic and political thinker Raymond Williams described democracy as a "long revolution" in Western societies. He insisted that even in the second half of the twentieth century, we were still at an early stage in learning the practices of democracy—and that one of the most urgent tasks of our societies was to invent and cultivate such practices. That task is more urgent today than ever.

My own experience in Bethlehem over the last three years has convinced me that universities can—if they choose—play an important role in this ongoing process. They can foster the production, preservation, and dissemination of knowledge about the most urgent problems we face, locally as well as globally. They can bring people together—not merely students and teachers, but people throughout their wider communities—to deliberate. They have the resources, stature, and influence to bring government officials together with the people who have elected them—or to bring corporate developers together with the people whose community is in the process of transformation. They can disseminate knowledge more widely, more variously—and, oddly enough, more locally—than they currently do. They can, in short, help us become more answerable to one another. ■

Seth Moglen, Associate Professor of English and Co-Director of the South Side Initiative at Lehigh University, was the 2009–10 Friends of the Institute for Advanced Study Member in the School of Social Science. *This article is based on a Friends Forum talk given on April 28. A video of the full talk is available online at www.ias.edu/people/friends.*

A Distorted View of History Led America Astray

BY JACK F. MATLOCK JR.

REAGAN PRESIDENTIAL LIBRARY

U.S. President Ronald Reagan meets with Soviet General Secretary Mikhail Gorbachev during the Reykjavik Summit in October 1986. Jack F. Matlock Jr., who was then Special Assistant to the President and Senior Director of European and Soviet Affairs at the National Security Council, is at the far right. In 1987, he became U.S. Ambassador to the Soviet Union.

Several years ago, I was increasingly disturbed by the direction taken by American foreign and domestic policy. It seemed to me that many key actions were inspired by mistaken notions about the way the Cold War ended and the causes and implications of the Soviet collapse. Lessons that I, a witness to those events from senior levels of government, thought were obvious were either ignored or turned on their head, and broad theories with little footing in reality seemed to dominate the thinking of policy makers, both in the United States and in other countries.

Having described the development of American policy that produced a negotiated end to the Cold War in *Reagan and Gorbachev: How the Cold War Ended* (2004), and recounted the way the Soviet Union fragmented into fifteen successor states in *Autopsy on an Empire* (1995), I resolved to describe the lessons I would draw from the geopolitically seismic events of 1988–91, and to consider how American policy might still profit from a better understanding of those events.

My thoughts are set forth in *Superpower Illusions: How Myths and False Ideologies Led America Astray—And How to Return to Reality*, published by Yale University Press (2010). In it I argue that myths about the way the Cold War ended, along with ideologies divorced from reality, led America into a series of blunders that drained its power and increased the dangers to its national security. I would summarize some of these mistaken ideas as follows:

Myth #1: The Cold War ended with the collapse of the Soviet Union.

NO! It ended well before the Soviet Union broke up.

Myth #2: Military and economic pressure destroyed Communist rule in the USSR.

NO! Mikhail Gorbachev undermined the Party's control of the country because it was blocking the reforms he considered necessary.

Myth #3: The USSR collapsed under pressure from the United States and its allies.

NO! Internal contradictions caused its collapse, not external pressure.

These myths stem from a tendency to conflate three geopolitically seismic events that were separate, though connected:

- The end of the Cold War (1988–89)
- Weakening of Communist Party control of the USSR (1989–91)
- Breakup of the Soviet Union (December 1991)

The Cold War ended peacefully, by negotiation, on terms that were in the interest of a reforming Soviet Union. President Reagan had defined the terms of settlement on the basis of common interests. In time, Gorbachev accepted his agenda, since it was in the Soviet interest. As Gorbachev subsequently observed, "We all won the Cold War."

The end of the arms race permitted Gorbachev to concentrate on reform at home, which in turn led to his ending the Communist Party's monopoly of power, using contested elections as a major tool. President Reagan recognized, and stated publicly, that Gorbachev's Soviet Union was no longer an "evil empire."

While the United States supported the restoration of independence of Estonia, Latvia, and Lithuania, it favored Gorbachev's effort to create a voluntary federation of the remaining twelve union republics. The breakup of the USSR, caused by internal factors, was a defeat for American policy, not a victory.

Myth #4: Russia was defeated in the Cold War.

NO! Today's Russian Federation was not a party to the Cold War. It was part of a Communist-ruled empire. Its elected leaders in 1990 and 1991 were strongly pro-Western and aspired to replace communist with democratic values.

Myth #5: The Cold War should be considered World War III.

NO WAY! "Cold War" is a metaphor, not the real thing. There was never any direct combat between the United States and its allies with the Soviet Union. If there had been, we would probably not be here today to write about it.

The Cold War ended peacefully, by negotiation, on terms that were in the interest of a reforming Soviet Union. President Reagan had defined the terms of settlement on the basis of common interests. In time, Gorbachev accepted his agenda, since it was in the Soviet interest. As Gorbachev subsequently observed, "We all won the Cold War."

The myths are also connected with the mistaken notion of "superpower." The United States and the USSR were considered superpowers because they had the means to destroy the world. They were not superpowers in the sense that they could change the world using their superior military power. The end of the Cold War diminished American power since much of it had derived from its ability to defend countries against Communist aggression and infiltration. The world did not suddenly become "unipolar;" there was not even a "unipolar moment." (So far as the power to destroy the world is concerned, the United States and Russia both still have that capability with their nuclear arsenals.)

While not a superpower in the sense that it could successfully rule other countries, the United States emerged from the Cold War the preeminent power in the world. It had the opportunity to create a safer world by strengthening international structures to deal with local conflicts, failed states, organized crime, and the threat of terrorism. It had the opportunity to reduce its military commitments abroad (there was no longer a Soviet Union to contain) and to accelerate the destruction of nuclear weapons started by Reagan, Bush I, and Gorbachev. Nevertheless, the Clinton administration, lacking a coherent strategy, was drawn into local conflicts not vital to U.S. security and without UN Security Council authority. It failed to bring Russia into the European security structure as a responsible partner and treated it as a defeated nation, thus undermining the prospects for democracy there and Russia's full cooperation in dealing with global issues.

If the Clinton administration missed opportunities, the Bush–Cheney administration destroyed them. Having ignored warnings of an impending terrorist attack on the United States—which could and should have been prevented—it invaded Iraq without adequate cause or international sanction, ignored or withdrew from treaty commitments, stalled verified nuclear arms reductions, and took a series of actions that encouraged rather than deterred nuclear weapons proliferation. It is ironic that a president who professed to admire President Reagan followed policies that were often the opposite of his, both in substance and in execution.

Myths about the Cold War and its end combined with theories taken to logical but unrealistic extremes undermined America's strength at home. Market fundamentalism ruled the day and loosening of controls on banks and financial markets contributed to the subprime bubble and a near collapse of the financial system in 2008. Tax cuts despite two wars produced an unprecedented budget deficit, and the country as a whole began to live beyond its means, even as education and infrastructure were allowed to deteriorate. The United States became the world's largest debtor at the very time it was experiencing the woes of imperial overstretch.

Meanwhile what passed for political debate at home was reduced to distorted slogans. The very meaning of many terms came under assault. There is nothing "conservative" about running large budget deficits, invading countries that are no direct and imminent threat, and exaggerating and sometimes fabricating intelligence reports, yet political spinmasters convinced a significant portion of the public that radical, high-risk, arguably illegal policies were "conservative." In fact, foreign policy cannot be calibrated on a "conservative–liberal" scale, and neither can many domestic issues.

The Obama administration has made a start, turning the ship of state toward a more constructive course in such areas as the wars in Iraq and Afghanistan, nuclear weapon issues in Iran and North Korea, relations with Russia, nuclear arms reduction, missile defense, and the Israeli–Palestinian problem. Though President Obama has, in general, set a moderate course of change, obstacles both abroad and at home are substantial. He still must deal with damage to the nation inherited from past administrations and overcome entrenched special interests—some in his own administration—that resist change. Nevertheless, the change of course that resulted in the recent agreement with Russia to eliminate more strategic nuclear missiles in a verifiable fashion has been a signal achievement. ■

Jack F. Matlock Jr. was George F. Kennan Professor in the School of Historical Studies from 1996 to 2001 and U.S. Ambassador to the Soviet Union from 1987 to 1991.

Why Jihad Went Global

BY THOMAS HEGGHAMMER

Member Thomas Hegghammer has linked the globalization of jihad to the rise of a pan-Islamic identity movement, fueled by publications such as this book by Abdallah Azzam, The Defense of Muslim Lands, the Most Important Personal Duty, *originally published in 1984. It was among the first to argue that Muslims had a duty to fight in other Muslims' wars.*

Jihadism today has a strong transnational and anti-Western character, but this was not always the case. The first jihadists were revolutionaries who fought in their home countries against their respective governments from the 1940s onward. Only in the 1980s did they start crossing borders—mostly to join the anti-Soviet war in Afghanistan—and it was not until the 1990s that they began targeting Westerners. As late as 1992, no American had ever been killed by Sunni Islamists, a fact that is easy to forget in the post-9/11 world.

Put simply, there are two competing explanations for why jihad went global in the 1990s. The first sees Islamist violence as a fundamentally religious phenomenon whose direction is determined by a combination of Islamic theology and modern ideological innovation. If jihadism globalized, it is because ideologues such as Osama bin Laden came along and articulated a new anti-Western strategy. The second explanation views Islamist violence as the expression of political grievance and as a reaction to international political developments. If jihadists shifted focus in the 1990s, it is because international politics changed—America became the sole superpower, and Western military penetration of the Muslim world increased. However, both explanations have limitations. The ideological hypothesis attributes ideological change to the creativity of individual ideologues without explaining why only some ideologies resonate while most others disappear. Meanwhile, the political explanation does not really match the empirical evidence. It is true that limited U.S. meddling in the Middle East began in the 1950s (with the Mosaddeq coup in Iran), but only after 2001 did the United States directly invade and occupy Muslim countries. So why did Al-Qaeda start attacking America in the 1990s?

I spent the past year at the Institute writing a book about Arab volunteer fighters in the 1980s Afghanistan war, a project that explores the roots of transnational Islamist militancy. In it, I propose a third explanation, which links the globalization of jihad to the rise of a pan-Islamic identity movement driven by elite competition within the Muslim world. The identity movement, or "macro-nationalism," was based on the view that all Muslims are one people and face an outside threat from non-Muslims. Its cradle was the western Hijaz region of Saudi Arabia, where several international Islamic organizations such as the Muslim World League were established in the 1960s and 1970s. These organizations were staffed in large part by highly educated Islamists from Egypt, Syria, and Iraq who had fled repression at home. The activists were isolated from any domestic political arena, but free to work in the international Islamic NGO sector. To increase their own budgets and political relevance, they constructed a new type of discourse emphasizing outside threats to the Muslim nation and the virtues of Muslim solidarity. They propagated the message through a variety of channels, notably a host of magazines distributed across the Muslim world. The magazines reported news from across the *umma* (Muslim nation), with a special focus on Muslim casualties in interreligious wars and the plight of Muslim minorities. The discourse was alarmist, conspiratorial, and xenophobic, but Muslim governments tolerated it for fear of appearing unsolidary toward suffering Muslims. While most Hijazi pan-Islamists advocated only nonviolent action such as humanitarian aid, some ideologues soon began arguing that the outside threat to the Muslim nation required a military response. During the Soviet occupation of Afghanistan in the 1980s, the Palestinian scholar Abdallah Azzam issued *fatwas* declaring it a duty for all Muslims to get involved in other Muslims' wars of national liberation. Azzam also spearheaded the mobilization of Arab volunteer fighters to Afghanistan in the 1980s, the first in a series of "foreign fighter" contingents that would enter Bosnia, Chechnya, Iraq, and other places. In the early 1990s, the notion of a beleaguered *umma* inspired an even more radical political project. A small group of battle-hardened "Arab Afghans" led by Osama bin Laden came to view conventional warfare as insufficient for fending off what they saw as a coordinated assault on the Muslim nation. Asymmetrical tactics were required, and they should be directed at the United States, the leader of the "Jewish-Crusader Alliance." In 1998, Bin Laden issued a landmark statement declaring it legitimate for Muslims to kill Americans, civilian as well as military, with any means in any place. However, Al-Qaeda attracted recruits through the same victim narrative as more moderate pan-Islamists. The globalization of jihad can thus be viewed as a three-stage process by which elite competition first produced soft pan-Islamism, which was then militarized, and then "anti-Westernized." Global jihadism is indeed an ideological phenomenon, but one that has more in common with nationalism than religious cults. Moreover, Western policies in the Middle East have often fuelled it, but mainly because there existed an extreme sensitivity to such policies in the first place. Besides, to the extent that material Muslim suffering fuelled pan-Islamism in the 1990s, most of this suffering was not inflicted by America, but by other non-Muslim powers: Serbs in Bosnia, India in Kashmir, Russia in Chechnya, and Israel in Palestine. While each of these conflicts had distinct local dynamics, the pan-Islamists saw them as connected.

Most observers agree that anti-Western jihadism has been in slow decline since the mid-2000s. Al-Qaeda and its affiliates have seen their operational capabilities blunted by counterterrorism efforts, while their popular support has waned as a result of violent excesses in Iraq and elsewhere. Global jihadism will likely not go away in a decade, but we may have seen the worst of it. ■

Thomas Hegghammer was the 2009–10 William D. Loughlin Member in the School of Historical Studies. Hegghammer is a senior fellow at the Norwegian Defence Research Establishment (FFI) in Oslo and the author of Jihad in Saudi Arabia: Violence and Pan-Islamism since 1979 *(Cambridge University Press, 2010) and coauthor of* Al Qaeda in Its Own Words *(Harvard University Press, 2008).*

FUNDAMENTAL LEMMA *(Continued from page 5)*

functoriality beyond endoscopy, which only analyzes representations of G in terms of representations of its endoscopic groups. For Langlands, it is not the fundamental lemma that is critical for the analytic theory of automorphic forms and for the arithmetic of Shimura varieties; it is the stabilized (or stable) automorphic trace formula that the fundamental lemma now establishes, namely, the reduction of the Arthur-Selberg trace formula to a stable trace formula for a group and its endoscopic groups, as well as the stabilization of the geometric Grothendieck-Lefschetz trace formula. "None of these are possible without the fundamental lemma, and its absence rendered progress almost impossible for more than twenty years," comments Langlands. "I hope that with the fundamental lemma at hand we will see in the coming years great progress both with functoriality and with the general theory of Shimura varieties."

In the past year, Langlands and Ngô wrote a paper with former Member Edward Frenkel (to be published in *Annales des sciences mathématiques du Québec*) in which the stable trace formula allows the introduction of the Steinberg-Hitchin base and of the Poisson summation formula.[12] They observe a close relationship between the trace formula and Beilinson-Drinfeld's conjecture in the geometric Langlands program. In a related work,[13] Frenkel and Witten have used the mirror symmetry of the Hitchin fibrations to expose the special role played by endoscopy in the geometric Langlands correspondence. This correspondence has been interpreted as the mirror symmetry of the Hitchin fibrations for two dual reductive groups.

Speaking of Ngô's geometric interpretation of the identities of orbital integrals for his proof of the lemma, Langlands says, "I am only very, very slowly coming to appreciate that Ngô's point of view on orbital integrals might supplement in important ways, maybe even replace, that of Harish-Chandra's. Certainly, it will be important for many other matters connected with invariant harmonic analysis, not just the fundamental lemma. From a technical point of view, I think that Ngô's work offers tools that Harish-Chandra didn't have, and they would have been a big help to him. I think it would have helped him see many things more clearly." ■

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2 http://publications.ias.edu/rpl_works/L8/debuts/traces-ps.pdf

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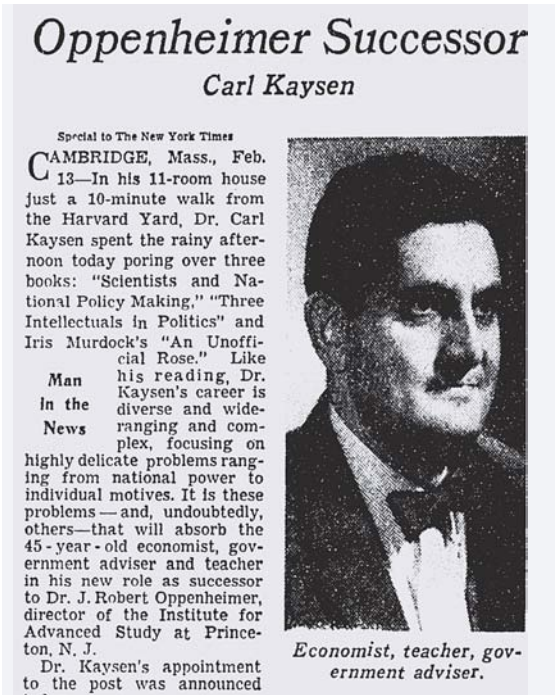
Freeman Dyson: Reflections on a Friendship with Carl Kaysen

Carl Kaysen, the Institute's Director from 1966–76, died on February 8, 2010, at the age of eighty-nine. A political economist with a distinguished career in public service, Kaysen used his tenure at the Institute to broaden its academic scope, including creating the School of Social Science, which was formally established in 1973.

Freeman Dyson, Professor Emeritus in the School of Natural Sciences, has worked with six Directors since joining the Faculty of the Institute in 1953. He gave the following remarks at a memorial for Kaysen held at the American Academy of Arts and Sciences on May 22.

Carl was my close friend, and I was fighting by his side for the ten years from 1966 to 1976 that he was Director of the Institute for Advanced Study. I was sorry that I saw little of him after he left Princeton. We stayed friends, and I would sometimes get delightful hand-written letters from him. One of the last came three years ago. Here is an extract from it, in memory of our friendship. It shows Carl at eighty-six remaining as bright and good-humored as he was in Princeton thirty years earlier. He is writing from MIT on November 9, 2006.



Oppenheimer Successor

Carl Kaysen

Special to The New York Times

CAMBRIDGE, Mass., Feb. 13—In his 11-room house just a 10-minute walk from the Harvard Yard, Dr. Carl Kaysen spent the rainy afternoon today poring over three books: "Scientists and National Policy Making," "Three Intellectuals in Politics" and Iris Murdock's "An Unofficial Rose." Like his reading, Dr. Kaysen's career is diverse and wide-ranging and complex, focusing on highly delicate problems ranging from national power to individual motives. It is these problems—and, undoubtedly, others—that will absorb the 45-year-old economist, government adviser and teacher in his new role as successor to Dr. J. Robert Oppenheimer, director of the Institute for Advanced Study at Princeton, N. J.

Man in the News

Dr. Kaysen's appointment to the post was announced

Economist, teacher, government adviser.

A New York Times article announcing Carl Kaysen's appointment as Director of the Institute

Dear Freeman,

> I read with great pleasure your account in *Technology Review* of life at Bomber Command during World War Two. It brought back memories of my semi-parallel activities at the time, as well as the occasion when I was driving you from Princeton to Cape Cod and we got so involved in exchanging World War Two reminiscences that I forgot to look at the gas gauge. The result: the spectacle of the Director of the Institute for Advanced Study and one of its professors pushing a Volkswagen along the Jersey Turnpike to the fortunately nearby service station.

Carl was always like that. He knew how to make the best of a bad situation. A bad situation became bearable when he treated it with a big dose of irony.

As you all know, Carl was in a bad situation at Princeton when he established the School of Social Science at the Institute for Advanced Study. Some Institute mathematicians had never forgiven the Institute Trustees for appointing Robert Oppenheimer as Director twenty years earlier. They decided to take their revenge on Carl. They organized a noisy public campaign against Carl, rather like the campaign of the tea-party Republicans against Obama. I was asked by the Institute Trustees to write a statement of my views, and here is the gist of what I wrote. "Carl Kaysen is as good a Director as we are likely to get and better than we deserve. He has made great efforts under difficult conditions to establish a first-rate program in social science. . . . During the nearly twenty years that I have been a member of the Faculty, a number of my colleagues have been slandering, harassing, and intriguing against the Director. It seems to make no difference who the Director is or what he is trying to do. . . . I cannot take seriously the pretensions of the Faculty to collective wisdom in the governance of the Institute. For twenty years our Faculty meetings have been distinguished by an astonishingly low level of discourse. . . . The Director is doing his job well, and will continue to do so provided that the Board continues to support him. Our internal problems are not worth more than twenty minutes of a busy man's time."

Carl stood firm and ended his ten-year tenure as Director with the Institute peaceful and the School of Social Science running smoothly. During the time of troubles, when insults and threats were flying freely, Carl kept cool. He called the affair the Froschmäusekrieg, the war of frogs and mice. He got this word from Helen Dukas, the secretary of Albert Einstein, who got it from Einstein. Einstein had used it to describe a famous squabble that happened in 1928 between two groups of European mathematicians. The original Froschmäusekrieg was a fight about the editorship of the German mathematics journal *Mathematische Annalen*. Einstein wrote in one letter: "This ink war would for me be one of the most funny and successful farces performed by people who take themselves deadly seriously," and in another: "With best wishes for an ample continuation of this noble and important battle, I remain yours truly, A. Einstein." Carl was like Einstein, viewing the strange antics of mathematicians with amused detachment. One year after he left Princeton, Carl wrote me a letter summing up his experience as Director. "Despite the quarrels and pains, it was worth the ten years. I really believe we left the place better than we found it; and I suppose to ask for more, or to expect gratitude, is to seek to transcend the human condition. And that would be impious."

I am supposed to talk only for five minutes, and so I cannot tell you how much I learned from Carl about the big world outside Princeton in which he played an active part. To give you the flavor of Carl as he performed on the national scene in Washington, I end with a quote from his testimony before the Foreign Relations Committee of the United States Senate on November 24, 1970. In reply to a question by Senator Case of New Jersey, he says: "I think if the government of country X is content to have its people buy Coca-Cola, it would be most unwise for the Government of the United States to say, 'That isn't good for you; you really ought to spend that money on milk, or you really ought to spend that money on roads, or something of the sort.' I just don't think that would be wise." Carl had a wonderful gift for demolishing lofty pretensions with simple facts. He lived in the real world. He did not expect our gratitude, but he earned it. ■

EINSTEIN LEGACY SOCIETY

Asset Allocation Strategies for the New Decade

KATE ABLUTZ

The Einstein Legacy Society, which recognizes those who have made commitments to the Institute through their estate plans or a planned gift, hosted a panel discussion on June 17 on "Asset Allocation Strategies for the New Decade." The discussion was led by Martin L. Leibowitz (far left), a Managing Director of Morgan Stanley and Trustee of the Institute for Advanced Study. Leibowitz serves as Vice Chairman of the Institute's Board of Trustees and President of the Corporation, and was Chairman of the Board from 2007–08. He recently coauthored The Endowment Model of Investing: Return, Risk, and Diversification *(Wiley Finance Editions, 2010), with Anthony Bova and P. Brett Hammond. Joining Leibowitz on the panel were Robert Litterman (center), a retired Partner of Goldman Sachs & Co. and codeveloper of the Black-Litterman Global Asset Allocation Model, and John L. (Launny) Steffens (far right), Founder and Managing Director of Spring Mountain Capital. The discussion may be viewed online at www.ias.edu/support/planned-gifts. For more information on the Einstein Legacy Society, please contact Catie Newcombe, Senior Development Officer, at (609) 951-4542 or cnewcombe@ias.edu.*

John Rassweiler, Leading the Friends by Example

John Rassweiler, Chair of the Friends of the Institute for Advanced Study since 2008, stepped down at the end of June after leading the Friends through two years of achievement and growth. Carolyn Sanderson, who has served as Vice Chair of the Friends and Chair of the Membership Committee, has been elected to succeed Rassweiler.

The founder and former President of Health Enhancement Systems, Inc., now retired, Rassweiler channeled his expertise in management to greatly benefit the Friends, which he joined in 1992 and to whose Executive Committee he was elected in 2002. His chairmanship was marked by incredible success in raising funds to support the Institute. In fiscal year 2009, Friends contributed nearly $583,000—an increase of $20,000 over the prior year. In fiscal year 2010, Friends contributed more than $714,000, thanks to Rassweiler's effective leadership in the effort to match a generous challenge gift from Friends Helen and Martin Chooljian.

Rassweiler's many other accomplishments include guiding the Executive Committee in developing a formal set of annual objectives and directing efforts to meet them. He formed two new subcommittees: Development and Community Relations, which supports the Institute's fundraising efforts and helps to articulate the Institute's mission, purpose, and accomplishments to the Friends and to the wider community; and Stewardship, which aims to welcome and orient new Friends and retain current Friends.

Rassweiler also reformed existing subcommittees and clarified their function and goals, including working with the Nominating Committee and its Chair, John Kerr, to identify and recruit new board members. Eight new members were elected during Rassweiler's tenure: Cynthia Hillas, Francesca Liechenstein, Lewis Maltby, and Yuh Schabacker-Koppel in 2009, and Martin Chooljian, Victoria Corrodi, Lucas Visconti, and John Wellemeyer in 2010. Rassweiler also oversaw a drive to recruit new Friends. The Membership Committee, under the leadership of Carolyn Sanderson, stepped up its outreach efforts with great results. Twenty-six new members joined the Friends in fiscal year 2009 and thirty-nine joined in fiscal year 2010.

ANDREA KANE

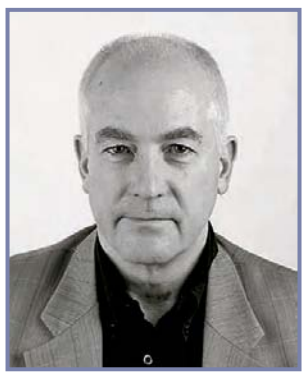
John Rassweiler and Carolyn Sanderson at the annual meeting of the Friends of the Institute for Advanced Study in May

Rassweiler's maxim is leadership by example. He was the first to step up to the Chooljian challenge, raising his annual contribution from the Director's to the Chairman's Circle level. At the same time, Rassweiler announced his decision to incorporate in his estate plans a bequest to the Institute, and he made clear his hope that other Friends would follow by increasing their annual giving, including the Institute in their estate plans, or both.

Peter Goddard, Director of the Institute, commented, "John Rassweiler has been an exemplary Chair of the Friends. The perspectives he has brought to the Friends from his business experience and his voluntary work in many community organizations have been of great value to us. We are most grateful to John for his commitment to the Institute and for all he has done to further our mission." ■

For information on becoming a Friend of the Institute, contact Pamela Hughes, Senior Development Officer, at (609) 734-8204 or phughes@ias.edu. Additional information is also available at www.ias.edu/people/friends.

Verellen Charitable Gift Supports IAS



Franciscus Verellen

During his 2009–10 Membership in the School of Historical Studies, Franciscus Verellen worked to complete a first draft of a book on medieval Chinese religion and explored new directions for future research and writing. Professor of Chinese Religion at the École Française d'Extrême-Orient, Verellen was recently appointed to a second five-year term as its Director.

"I was moved to experience the famed hospitality of the Institute, the wealth and variety of intellectual exchange and academic resources, along with the magnificent environment and quality support it provides," Verellen writes. "My wife Isabelle, besides her personal pursuits, enjoyed attending lectures and participating in After Hours Conversations, as well as renewing and adding fresh ties of friendship to North America and other parts of the world."

In appreciation of their experience at the Institute, the Verellens recently established a charitable gift annuity. A charitable gift annuity is a popular philanthropic strategy because of its many benefits and the ease with which it can be established. It is a simple contract between a donor and a grantor (such as the Institute for Advanced Study), in which the donor makes a gift in exchange for a stream of annuity payments to one or two individuals during their lifetimes. Donors can establish annuities for themselves and/or a spouse, for their parents, or to support a relative or a friend. Donors can elect to begin receiving annuity payments immediately or defer payments to a later date.

Speaking of the gift, which will provide deferred annuity payments throughout his retirement and will ultimately benefit the Institute, Verellen comments, "We feel privileged to add our stone to this inspiring edifice." ■

The Institute is qualified to grant charitable gift annuities in New Jersey and in many other states. An irrevocable gift of at least $10,000 is required to establish a charitable gift annuity, and the annuitant must be at least sixty years old when income payments begin. Individual annuity rates, which range from 5 percent to 9.5 percent depending on the annuitant's age, will be higher if the gift is made now and the payments are deferred. Donors are eligible for an immediate charitable income-tax deduction. Capital-gains taxes are deferred if the annuity is funded with appreciated assets such as stock. In addition, a portion of each annuity payment is tax-exempt. To explore how a CGA might work for you, please contact Catie Newcombe, Senior Development Officer, at (609) 951-4542 or cnewcombe@ias.edu. If you wish to calculate payments yourself, access the Planned Giving Calculator at wwww.ias.edu/support/planned-gifts. All calculations are anonymous unless you indicate you wish to be contacted.

Charles Simonyi's Return to Space

ANDREA KANE

Charles Simonyi, Chairman of the Institute's Board of Trustees, is the only "space tourist" to fly twice—first in 2007 and most recently in 2009, for a combined total of twenty-eight days in space. Simonyi gave a public lecture at the Institute in May in which he described daily life in a spacecraft and on the International Space Station and showed footage of his dynamic return trip from orbit. The full presentation can be viewed at http://video.ias.edu/return-to-space.