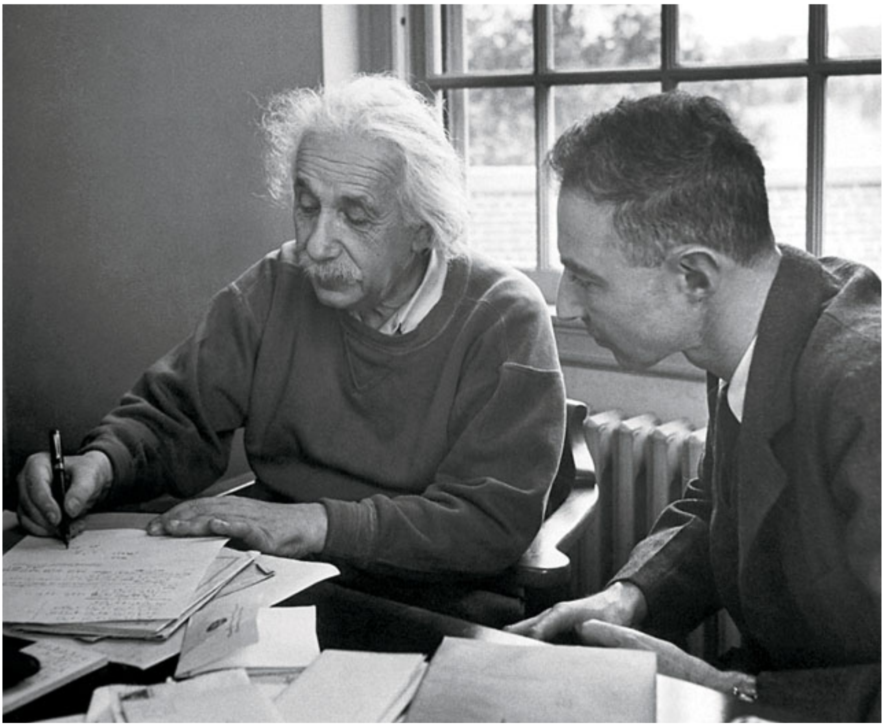
IAS
The Institute Letter
Summer 2011



TIME & LIFE PICTURES/GETTY IMAGES

Black Holes and Quantum Mechanics

In a paper written in 1939, Albert Einstein attempted to reject the notion of black holes that his theory of general relativity and gravity, published more than two decades earlier, seemed to predict. "The essential result of this investigation," claimed Einstein, who at the time was six years into his appointment as a Professor at the Institute, "is a clear understanding as to why the 'Schwarzschild singularities' do not exist in physical reality."

Schwarzschild singularities, later coined "black holes" by John Wheeler, former Member in the School of Mathematics, describe objects that are so massive and compact that time disappears and space becomes infinite. The same year that Einstein sought to discount the existence of black holes, J. Robert Oppenheimer, who would become Director of the Institute in 1947, and his student Hartland S. Snyder used Einstein's theory of general relativity to show how black holes could form. The above photo, taken at the Institute in the late 1940s, shows Oppenheimer with Einstein. According to Jeremy Bernstein, a physicist, author, and former Member in the School of Mathematics, it is unknown whether Einstein and Oppenheimer ever discussed black holes, but neither worked on the subject again.

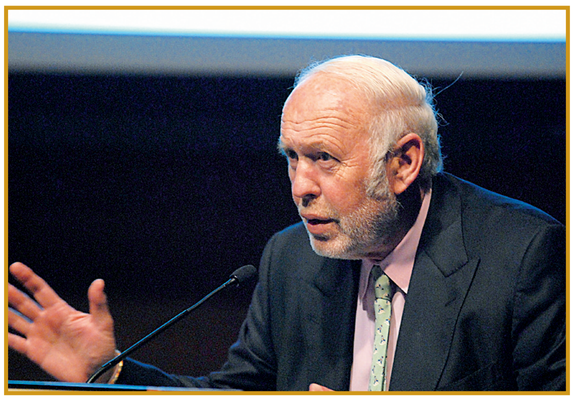
In the following pages, Juan Maldacena, Professor in the School of Natural Sciences, explains the development of a string theoretic interpretation of black holes where quantum mechanics and general relativity, previously considered incompatible, are united. Work by Maldacena and others has given a precise description of a black hole, which is described holographically in terms of a theory living on the horizon. According to this theory, black holes behave like ordinary quantum mechanical objects—information about them is not lost, as previously thought, but retained on their horizons—leading physicists to look at black holes as laboratories for describing the quantum mechanics of spacetime and for modeling strongly interacting quantum systems.

The Institute Letter

Institute for Advanced Study | Summer 2011

IAS Receives $100 Million Challenge Grant: Largest Donation Since Founders' Gift

Lead Gifts from the Simons Foundation and the Charles and Lisa Simonyi Fund for Arts and Sciences Launch $200 Million Campaign



CLIFF MOORE

James H. Simons

The Institute for Advanced Study has received a $100 million unrestricted challenge grant from the Simons Foundation and the Charles and Lisa Simonyi Fund for Arts and Sciences. This donation, which is the largest since the founders' gift establishing the Institute in 1930, will serve as the basis for a $200 million campaign to strengthen the Institute's endowment. This grant must be matched by funds from donors within the next four years; additional gifts and pledges of $9 million have already been received. All funds received will be matched dollar for dollar by the Simons Foundation and the Simonyi Fund.

The $200 million campaign will ensure that the Institute is able to continue its essential role in fostering fundamental research in the sciences and humanities. The main goal of the campaign is to raise new endowment funds that will allow the Institute to keep its draw on the endowment at an acceptable level over the long term. The stability and health of the Institute's endowment is essential for its financial independence because it relies on endowment income for approximately three-quarters of its operating expenses. This campaign will build upon the successful completion of the Institute's most recent campaign, launched in 2004, which raised $135 million from more than 1,500 donors, including Trustees, Faculty, Staff, former Institute scholars, Friends of the Institute, foundations and donor-advised funds, and others.

"The Institute is immensely grateful to the Simons Foundation and the Simonyi Fund for this extremely generous and far-sighted donation, which is of historic importance for the Institute," commented Peter Goddard, Director of the Institute. "The Institute was founded in 1930 by Caroline and Louis Bamberger, enlightened philanthropists who believed in the need to provide the world's leading scholars with the support and facilities that would enable them to pursue curiosity-driven research that would enlarge our understanding of the world, leading to both cultural and practical benefits for mankind. Their vision is as relevant today as it was eighty years ago, and this magnificent challenge grant initiates a campaign that will ensure that the Institute will be able to fulfill its mission in the future, sustaining a unique scholarly environment and providing researchers drawn from institutions around the world with the freedom they need for fundamental research."

CLIFF MOORE

Charles Simonyi

The Simons Foundation, which seeks to advance the frontiers of research in the basic sciences

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Is the Solar System Stable?

BY SCOTT TREMAINE

The stability of the solar system is one of the oldest problems in theoretical physics, dating back to Isaac Newton. After Newton discovered his famous laws of motion and gravity, he used these to determine the motion of a single planet around the Sun and showed that the planet followed an ellipse with the Sun at one focus. However, the actual solar system contains eight planets, six of which were known to Newton, and each planet exerts small, periodically varying, gravitational forces on all the others. The puzzle posed by Newton is whether the net effect of these periodic forces on the planetary orbits averages to zero over long times, so that the planets continue to follow orbits similar to the ones they have today, or whether these small mutual interactions gradually degrade the regular arrangement of the orbits in the solar system, leading eventually to a collision between two planets, the ejection of a planet to interstellar space, or perhaps the incineration of a planet by the Sun. The interplanetary gravitational interactions are very small—the force on Earth from Jupiter, the largest planet, is only about ten parts per million of the force from the Sun—but the time available for their effects to accumulate is even longer: over four billion years since the solar system was formed, and almost eight billion years until the death of the Sun.

DENISE APPLEWHITE/PRINCETON UNIVERSITY

This 240-year-old mechanical model known as the Rittenhouse Orrery, housed in Peyton Hall at Princeton University, shows the arrangement of the solar system.

Newton's comment on this problem is worth quoting: "the Planets move one and the same way in Orbs concentrick, some inconsiderable Irregularities excepted, which may have arisen from the mutual Actions of

(Continued on page 6)

Black Holes and the Information Paradox in String Theory

BY JUAN MALDACENA

The ancients thought that space and time were preexisting entities on which motion happens. Of course, this is also our naive intuition. According to Einstein's theory of general relativity, we know that this is not true. Space and time are dynamical objects whose shape is modified by the bodies that move in it. The ordinary force of gravity is due to this deformation of spacetime. Spacetime is a physical entity that affects the motion of particles and, in turn, is affected by the motion of the same particles. For example, the Earth deforms spacetime in such a way that clocks at different altitudes run at different rates. For the Earth, this is a very small (but measurable) effect. For a very massive and very compact object the deformation (or warping) of spacetime can have a big effect. For example, on the surface of a neutron star a clock runs slower, at 70 percent of the speed of a clock far away.

In fact, you can have an object that is so massive that time comes to a complete standstill. These are black holes. General relativity predicts that an object that is very massive and sufficiently compact will collapse into a black hole. A black hole is such a surprising prediction of general relativity that it took many years to be properly recognized as a

(Continued on page 4)

News of the Institute Community

JEAN BOURGAIN, Professor in the School of Mathematics since 1994, has been named the IBM von Neumann Professor in the School. He has also been elected to the National Academy of Sciences as a Foreign Associate.

ANGELOS CHANIOTIS, Professor in the School of Historical Studies, has received the 2010 Greek State Prize for Literature, awarded by the Greek Ministry of Culture and Tourism. Chaniotis received the prize in the essay category for his book *Theatricality and Public Life in the Hellenistic World*, published in Greek (Iraklion, Crete University Press 2009). Chaniotis was also appointed to the Scientific Board of the Belgian Fonds de la Recherche Scientifique (FNRS).

ERIC S. MASKIN, Albert O. Hirschman Professor in the School of Social Science, has received the 2011 FGC International Award for Economics presented by the Cristóbal Gabarrón Foundation in Spain.

AVI WIGDERSON, Herbert H. Maass Professor in the School of Mathematics, has been elected a member of the American Academy of Arts and Sciences. Thirteen former Institute Members and Visitors were also elected to the Academy's 2011 class.

ENRICO BOMBIERI, CAROLINE WALKER BYNUM, and ARNOLD J. LEVINE became Professors Emeritus as of July. Bombieri, a member of the Faculty of the School of Mathematics since 1977, had been the IBM von Neumann Professor in the School since 1984. Bynum has been a Professor in the School of Historical Studies since 2003, and Levine has been a Professor in the School of Natural Sciences since 2004.

CAROLINE WALKER BYNUM, Professor Emerita in the School of Historical Studies, has been awarded the Haskins Medal for her book *Wonderful Blood: Theology and Practice in Late Medieval Northern Germany and Beyond* (University of Pennsylvania Press, 2007). The medal, presented by the Medieval Academy of America, is awarded annually for a book in the field of medieval studies. Bynum recently has published *Christian Materiality: An Essay on Religion in Late Medieval Europe* (Zone Books, 2011). She is also the recipient of an honorary degree from the University of Glasgow.

Harvard University Press has published volume 3, books 5–8, of *The Histories by Polybius* (Loeb Classical Library, 2011), edited by CHRISTIAN HABICHT, Professor Emeritus in the School of Historical Studies, and F. W. Walbank and translated by W. R. Paton.

ROBERT P. LANGLANDS, Professor Emeritus in the School of Mathematics, has been awarded an honorary degree by the University of Chicago.

AVISHAI MARGALIT, former Professor (2006–11) in the School of Historical Studies, received the 2011 Dr. Leopold Lucas Prize at ceremonies in Germany in May. The prize is presented annually by the Faculty of Protestant Theology on behalf of the Eberhard Karls University, Tübingen. Margalit's term as George F. Kennan Professor in the School of Historical Studies, which he held since 2006, ended in July. He is now an Honorary Fellow at the Van Leer Jerusalem Institute.

RASHID SUNYAEV, the Maureen and John Hendricks Visiting Professor in the School of Natural Sciences, has been awarded the 2011 Kyoto Prize in Basic Sciences by the Inamori Foundation. The award acknowledges Sunyaev's development of a theory that allows the use of fluctuations in cosmic microwave background radiation to explore the expanding universe, and for his contributions to the field of high-energy astronomy.

MARIO DRAGHI, an Institute Trustee, has been appointed President of the European Central Bank effective November 1. Draghi is currently Governor of the Bank of Italy.

ROGER W. FERGUSON JR., an Institute Trustee, has been awarded an honorary degree by Michigan State University. Ferguson is President and Chief Executive Officer of TIAA-CREF.

MARTIN REES, an Institute Trustee and former Member (1969–70, 1973, 1975, 1982, 1992–93, 1996) in the School of Natural Sciences, has been awarded an honorary degree from the University of London. Rees is Master of Trinity College, University of Cambridge, where he is Professor Emeritus of Cosmology and Astrophysics.

JAMES D. WOLFENSOHN, Trustee Emeritus and Chairman Emeritus of the Institute, has been awarded an honorary degree by the Hebrew University of Jerusalem. Wolfensohn is Chairman of Wolfensohn & Company.

DAVIDE GAIOTTO, Member (2007–11) in the School of Natural Sciences, has been awarded the 2011 Gribov Medal for uncovering new facets of the dynamics of four-dimensional supersymmetric gauge theories and for his part in finding intricate relations between two-dimensional theories of gravity and four-dimensional gauge theories.

School of Mathematics Member MARK GORESKY and former Member JAYCE GETZ (2007–09) have been awarded the Ferran Sunyer i Balaguer Prize for their monograph "Hilbert Modular Forms with Coefficients in Intersection Homology and Quadratic Base Change," which will be published in Birkhäuser Verlag's series Progress in Mathematics. Getz is Assistant Professor of Mathematics at McGill University.

ÁLVARO PELAYO, Member (2010–11) in the School of Mathematics, has been awarded the Rubio de Francia Prize by the Royal Spanish Mathematical Society. The prize is awarded annually to a young mathematician from Spain or residing in Spain and is the highest distinction given by the society.

MICHAEL ASCHBACHER, former Member (1978–79) in the School of Mathematics, has been awarded the 2011 Rolf Schock Prize in Mathematics by the Royal Swedish Academy of Sciences. Aschbacher is Shaler Arthur Hanisch Professor of Mathematics at the California Institute of Technology.

School of Mathematics former Visitor (1983) and Member (1984) DEMETRIOS CHRISTODOULOU and former Member (1992) RICHARD HAMILTON have been awarded the 2011 Shaw Prize in Mathematical Sciences. They were honored for their work on nonlinear partial differential equations in Lorentzian and Riemannian geometry and their applications to general relativity and topology. Christodoulou is a Professor of Mathematics and Physics at the Eidgenössische Technische Hochschule Zürich and Hamilton is the Davies Professor of Mathematics at Columbia University.

INGRID DAUBECHIES, former Member (1999) in the School of Mathematics, has been awarded the 2011 Benjamin Franklin Medal in Electrical Engineering by the Franklin Institute for her fundamental discoveries in the field of compact representations of data, leading to efficient image compression. A Professor at Duke University, Daubechies has served on the organizing committee of Women and Mathematics, a joint program of the Institute and Princeton University, since the program's inception.

CORMAC Ó GRÁDA, former Member (2007) in the School of Historical Studies, has been awarded the Royal Irish Academy Gold Medal in the Humanities. Ó Gráda is Professor of Economics at University College Dublin.

HEISUKE HIRONAKA, former Member (1962–63) in the School of Mathematics, was among four individuals awarded the 2011 Centennial Medal by Harvard University's Graduate School of Arts and Sciences. Hironaka is Professor Emeritus at Harvard.

CHRISTOPHER P. JONES, former Member (1971–72, 1982–83) and Visitor (1987, 1990–91, 2005–06), and Corinne Bonnet, former Member (2009), both in the School of Historical Studies, have been elected to the Académie des Inscriptions et Belles-Lettres in Paris as correspondants étrangers. Jones is the George Martin Lane Professor of the Classics and of History at Harvard University. Bonnet is a Professor at the Université de Toulouse II Le Mirail.

RAMAKRISHNA RAMASWAMY, former Member (2004–05) in the School of Natural Sciences, has been named Vice-Chancellor of the University of Hyderabad.

ERIK VERLINDE, former Member (1988–93) in the School of Natural Sciences, has been awarded the 2011 Spinoza Prize by the Netherlands Organization for Scientific Research. Verlinde was recognized in part for the equations he formulated with Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, and former Members Herman Verlinde (2008–09) and Robbert Dijkgraaf (1991–92, 2002–03). Erik Verlinde is Professor of Physics at the University of Amsterdam.

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.

Letter from the Director

CLIFF MOORE

The global financial crisis of recent years has presented great challenges, directly or indirectly, to all academic institutions. Since its foundation, the Institute for Advanced Study has depended on its endowment to provide the basis of its financial stability: about three-quarters of its core operating expenses have been provided by income from our endowment. Although our investments have been wisely managed, and fared better than those of many other institutions in the financial downturn, it is imperative that we strengthen our endowment in order to make the financial future of the Institute secure.

In response to the financial crisis, we succeeded in reducing the Institute's projected expenditure by about a fifth for the academic years 2009–12 and, for each of these three years, the Board of Trustees with magnificent generosity have personally provided $10 million per year, reducing the pressure on the endowment while its value has been depressed. The economies that have been made have been chosen carefully so that, as far as possible, they are not damaging the academic life and work of the Institute, but they cannot all be continued at this level indefinitely, and nor should the Institute rely on annual donations of $10 million for essential core expenditure.

In order to secure the resources needed in the future for pursuing its mission of fostering fundamental research in the sciences and humanities, providing financial support and outstanding facilities for its Members and Faculty, the Institute must increase its endowment by $200 million, and so it is launching a campaign to raise this sum. Recently, the Institute received a $100 million challenge grant from the Simons Foundation and the Charles and Lisa Simonyi Fund for Arts and Sciences (see article, page 1). In order to secure this $100 million grant, the Institute has to raise matching donations totaling $100 million within four years, and this will achieve our $200 million target.

Last year, we were extremely pleased to receive record levels of donations both from former Members and from the Friends of the Institute. There are many ways of supporting the work of the Institute: with gifts of annual support, major gifts of endowment and program support, or with gifts made in conjunction with estate planning. All of these contributions will help the Institute match the $100 million challenge grant so generously provided by James H. Simons, Vice Chairman of the Institute's Board of Trustees, and Charles Simonyi, Chairman of the Board. We deeply appreciate all these endorsements of the value of the Institute's mission and the continuing relevance and importance for future generations.

—Peter Goddard

CAPITAL CAMPAIGN *(Continued from page 1)*

and mathematics across institutions and fields, was founded by James H. Simons, a Vice Chairman of the Institute's Board of Trustees and a Trustee since 2001, and his wife Marilyn Hawrys Simons. The Charles and Lisa Simonyi Fund for Arts and Sciences, which provides grants to organizations in the arts, sciences, and education, was established by Charles Simonyi, Chairman of the Institute's Board of Trustees and a Trustee since 1997. Both organizations have provided significant support to the Institute in the past decade. The Simons Foundation has funded numerous initiatives at the Institute, especially in the School of Natural Sciences' Simons Center for Systems Biology, which opened in 2007. The Center was named in honor of Jim and Marilyn Simons in recognition of the Foundation's generous challenge grant that provided support for operational costs and the establishment of an endowment fund.

The Institute was founded in 1930 by Caroline and Louis Bamberger, enlightened philanthropists who believed in the need to provide the world's leading scholars with the support and facilities that would enable them to pursue curiosity-driven research that would enlarge our understanding of the world, leading to both cultural and practical benefits for mankind.

Simons, who serves as Chairman of the Board at Renaissance Technologies LLC and President of Euclidean Capital LLC and was a Member (1972) in the Institute's School of Mathematics, said of the recent gift, "The health and viability of the Institute's endowment will ensure that the Institute can operate at its desired level and maintain the highest standards. Marilyn and I are committed to the Institute's mission and purpose, and are pleased to make this contribution."

Charles Simonyi donated the lead gift toward the Institute's previous capital campaign, establishing the Karoly Simonyi Memorial Endowment Fund in memory of his late father. He also endowed the Charles Simonyi Professorship in Theoretical Physics in 1997, held first and currently by Edward Witten, and has provided support to the Institute's School of Mathematics. Simonyi Hall, the building that houses the School, was dedicated in 2000 in recognition of his commitment to the work of the Institute.

"The Institute's role in promoting and cultivating original scholarship in the sciences and humanities is unparalleled," noted Simonyi, Chairman and Chief Technology Officer of Intentional Software Corporation. "It is of utmost importance to sustain the work of this institution of international renown and reach where scholars have the freedom to pursue their research in an environment dedicated to the advancement of ideas that change our understanding of the world. Lisa and I are honored to play a role in building a strong foundation for the Institute's future." ■

Institute Board Appoints Two New Trustees

Two new members have been appointed to the Board of Trustees of the Institute for Advanced Study. Cynthia Carroll, whose appointment was effective May 7, is Chief Executive of Anglo American plc in London, England. Carmela Vircillo Franklin, Professor of Classics at Columbia University, was nominated by the Institute's School of Historical Studies for a term beginning July 1. Franklin succeeds David A. Hollinger, Preston Hotchkis Professor of American History at the University of California, Berkeley, who served a five-year term.

ANGLO AMERICAN

Cynthia Carroll

Carroll, who is originally from Princeton, was appointed Chief Executive of Anglo American in March 2007. Anglo American, a major producer of copper, nickel, iron ore, coal, phosphates, and niobium, is one of the largest diversified mining companies in the world, with 85 percent of its operations in developing countries. Carroll received a B.S. in Geosciences from Skidmore College in 1978, an M.S. in Geology from the University of Kansas in 1982, and an M.B.A. from Harvard in 1989. She began her career with Amoco in oil and gas exploration in the western United States, in states including Wyoming, Colorado, Utah, and Montana. After earning her business degree, she joined the Canadian company Alcan and held a broad range of roles, including four years in Kentucky as general manager of a packaging company and three years in Ireland as managing director of Europe's largest alumina refinery. Her last five years at Alcan were spent as President and CEO of the Primary Metals business, which operated in twenty-five countries across South America, North America, Europe, and Africa. Carroll serves on the boards of BP and De Beers, and she is Chairman of Anglo American Platinum Limited, a South African subsidiary of Anglo American. She is a member of the American Society of Corporate Executives, a former Director of the Sara Lee Corporation, and has recently been appointed Chairman of the Stop Organised Abuse Board of the National Society for the Prevention of Cruelty to Children, a British nonprofit.

Franklin, a native of Italy, received a B.A. (1971) and Ph.D. (1977) in Classics from Harvard University. Her work focuses on medieval Latin texts and their manuscripts, and she conducts her research in Europe's great manuscript repositories, especially the Vatican Library and the Bibliothèque Nationale de France. In 1977, Franklin joined the faculty of the Department of History and the Department of Classics of St. John's University in Collegeville, Minnesota, where she served also as Chair of the Department of History from 1988 to 1992, and Interim Director of the school's Hill Monastic Manuscript Library. Franklin joined the faculty of Columbia University in 1993. From 2005 to 2010 Franklin served as Director of the American Academy in Rome, an institution for independent research in the humanities and advanced work in the arts. Franklin was awarded the Rome Prize as a Mellon Fellow in post-Classical Humanistic Studies in 1984–85, and was named the Lucy Shoe Meritt Resident in Classics in 2001–02 by the American Academy. Additional honors include the Centennial Medal of the American Academy in Rome, which she was awarded in 2010, and the Henry Allen Moe Prize in the Humanities from the American Philosophical Society in 2003. Franklin is a trustee of the Samuel H. Kress Foundation and a member of the editorial board of the journal *Traditio*. She was elected a Fellow of the Medieval Academy of America in 2008. ■

TIMOTHY GREENFIELD-SANDERS

Carmela Vircillo Franklin

prediction. Einstein himself thought it was not a true prediction, but a mathematical oversimplification. We now know that they are clear predictions of the theory. Furthermore, there are some objects in the sky that are probably black holes.

Black holes are big holes in spacetime. They have a surface that is called a "horizon." It is a surface that marks a point of no return. A person who crosses it will never be able to come back out. However, he will not feel anything special when he crosses the horizon. Only a while later will he feel very uncomfortable when he is crushed into a "singularity," a region with very high gravitational fields. The horizon is what makes black holes "black"; nothing can escape from the horizon, not even light. Fortunately, if you stay outside the horizon, nothing bad happens to you. The singularity remains hidden behind the horizon.

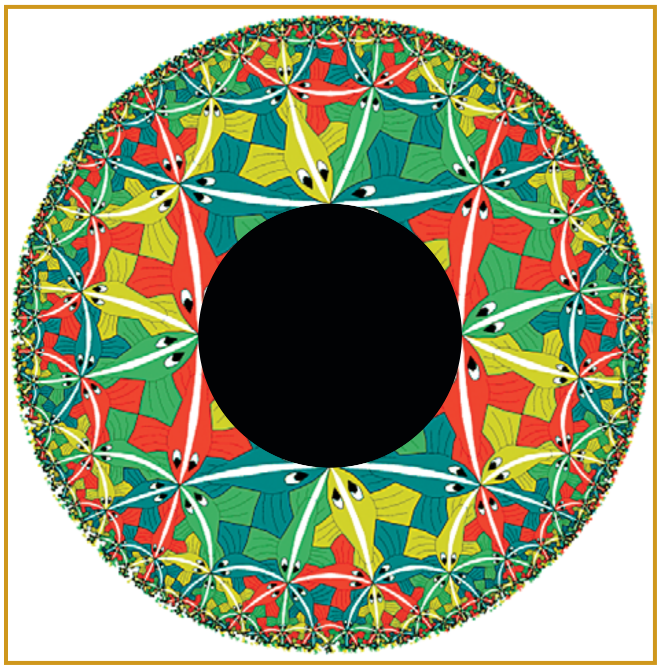
Something surprising happens when we take into account the effects of quantum mechanics. Due to quantum mechanical fluctuations near the horizon, black holes should emit radiation, called Hawking radiation. This is a famous theoretical prediction that Stephen Hawking made in the seventies. This means that black holes are not completely black. A black hole can glow, like an ember, or, if it is hot enough, you can even have the oxymoronic possibility of a *white* black hole. A black hole gets hotter the smaller it is. A white black hole should have the size of a bacterium, and the mass of a continent. Such black holes, while theoretically possible, are not known to be naturally produced anywhere in the universe. Black holes that are naturally produced have masses bigger than the Sun and sizes bigger than a few miles. Such black holes are also supposed to emit Hawking radiation, but it is swamped by other matter falling into the black hole. For this reason, Hawking radiation has not been directly measured. However, the argument leading to it is so solid that most scientists who have studied it think it is a very clear prediction. The existence of this radiation has important consequences. The first is that black holes have a temperature. We know that temperature is due to the motion of the elementary constituents of the object. For example, air is hotter or colder depending on whether air molecules are moving faster or slower. In the case of black holes, what is moving? Black holes only involve gravity, so what is moving is spacetime itself. Since the nineteenth century, we have understood that when we have thermal systems we can compute a quantity called the "entropy," which tells us about the number of microscopic configurations that the system has. From Hawking's formula for the temperature of a black hole one can also find this entropy. It turns out to be proportional to the area of the horizon, or the square of the mass of the black hole. This is also a bit strange. The entropy of almost every substance grows in proportion to the amount of substance that we have. Here it grows like the square. It is really a case of "the more the merrier."

Juan Maldacena, who first came to the Institute as a Member in 1999, has been a Professor in the School of Natural Sciences since 2002. He continues to study a relationship he has proposed between quantum gravity and quantum field theories in an effort to further understand the deep connection between black holes and quantum field theories as well as connections between string theory and cosmology.

A second consequence of Hawking radiation is that black holes lose mass, since they are radiating energy away. Thus, a black hole left alone in an otherwise empty universe would eventually completely disappear. We call this process "black hole evaporation," since the black hole appears to evaporate as a droplet of water.

Hawking radiation from black holes has given rise to very profound and interesting theoretical puzzles. Einstein has taught us that spacetime is a physical object. We also know that all other physical objects, such as those made with matter or radiation, obey the laws of quantum mechanics. Thus, spacetime should be no different and should also obey the laws of quantum mechanics. Any quantum mechanical theory of spacetime should be able to describe precisely how black holes form and evaporate. It should also give a precise explanation for the entropy of a black hole.

Here one finds an interesting paradox. Classically, all the information making the black hole has fallen inside. On the other hand, Hawking radiation implies that the black hole emits thermal radiation. This thermal radiation apparently carries no information about



A black hole in a negatively curved spacetime is described in terms of a quantum mechanical system living on the boundary of the spacetime. The boundary is the outer rim of the figure above (adapted from a picture of hyperbolic space by M. C. Escher).

the things that fell in, since this radiation is generated in the vicinity of the horizon. Thus the black hole can form in many different ways but it appears to evaporate always in the same way. This is a contradiction with standard quantum mechanics. In quantum mechanics (as in classical mechanics) the information about a system is not lost. Different initial conditions lead to different outcomes. It can be the case that sometimes the outcomes are very similar. For example, if one puts this article in a shredder, one seems to lose what was written

Spacetime should also obey the laws of quantum mechanics. Any quantum mechanical theory of spacetime should be able to describe precisely how black holes form and evaporate.

on it. However, one could, in principle, put it back together. Hawking suggested that black holes imply that this basic principle of quantum mechanics would not hold in the presence of gravity. Namely, the radiation coming out of black holes would be completely thermal and devoid of the information of what fell into black holes. Thus, black holes appear to be sinks of information, perverse monsters that threaten the fundamental laws of quantum mechanics.

String theory is a theory being constructed to describe the quantum mechanics of spacetime. As such, the theory should explain whether black holes are consistent with quantum mechanics or not. In fact, since string theory obeys the usual principles of quantum mechanics, we expect that information should not be lost in black holes. For this reason the problem of information loss was actively studied during the nineties. The problem was difficult in the original formulation of string theory because the quantum spacetime was described by starting with a flat spacetime and then considering small quantum fluctuations, or ripples, that propagate in it. As long as these ripples interact weakly with each other, the theory is relatively simple. However, in order to form a black hole you need a strong deviation from a flat spacetime. You need to put a lot of these ripples together, and by the time the black hole forms, the simplest formulation of string theory becomes unmanageable.

In the mid-nineties, Joseph Polchinski (at the University of California, Santa Barbara) made a breakthrough by discovering that string theory contains other objects, called D-branes. They have a strange name for reasons that are not important for us. You can mentally give them any other name that you find more pleasant. These are particle-like objects that are heavier than the spacetime ripples we discussed above. Nevertheless, one can give a very precise description for them within the rules of string theory. It soon became clear that they were ideally suited for studying black holes.

The description of a single D-brane is fairly simple. A single D-brane is very similar to a particle; it is characterized by its position in space. However, a single D-brane is not heavy enough to curve spacetime in a significant way. So, we need to bring many D-branes together. When we bring them together, there is a surprising new symmetry that emerges. In ordinary quantum mechanics, elementary particles are identical, in the sense that there is no way to distinguish them. The full description is completely invariant under the interchange of any two identical elementary particles, such as two electrons. D-branes are invariant under a bigger symmetry group: a full continuous symmetry, called a gauge symmetry. (For the mathematically oriented: this is the group $SU(N)$ versus the permutation group S_N). When N D-branes come together, the positions of the branes become N x N matrices. A matrix is an array of numbers. We would have expected that N branes are described by N positions, the positions of each of the objects individually. However, we find that they are described by N^2 numbers. The dynamics of these N^2 variables is governed by a gauge theory. Gauge theories are very important for the description of nature; we use them to describe three of the forces (the electromagnetic, the weak, and the strong). Now, if we want to separate the D-branes by a big amount, we find that there is a force that does not allow them to be separated unless the matrices are diagonal, reducing then to the usual description in terms of N identical particles. When all these D-branes are close together, the number of possible ways to arrange them grows very fast with its number. It grows like N^2, rather than the N expected for a usual extensive system.

This has become a bit abstract, so let us make an analogy. Say D-branes are people. Imagine that we have a group of N people (say N is a big number, e.g., a thousand). Now imagine that each person can be happy or sad. The entropy is just the information that you need to completely specify the emotional state of everybody. In this case you need to specify N bits of information: whether each of the N persons is happy or sad. If N is a thousand, you need a kilobit of information. On the other hand, imagine that each person can like or dislike every other person. Now to capture the complete set of likes or dislikes of everybody you need to give N^2 bits of information. If N is a thousand, you need a megabit of information. The case of black holes is similar to this latter situation, where one has to keep track of variables that involve pairs of D-branes, rather than single D-branes. In this analogy, you can only separate the D-branes when they dislike (and are disliked by) all the

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The Geometry of Random Spaces

BY MATTHEW KAHLE

I sometimes like to think about what it might be like inside a black hole. What does that even mean? Is it really "like" anything inside a black hole? Nature keeps us from ever knowing. (Well, what we know for sure is that nature keeps us from knowing *and* coming back to tell anyone about it.) But mathematics and physics make some predictions.

John Wheeler suggested in the 1960s that inside a black hole the fabric of spacetime might be reduced to a kind of quantum foam. Kip Thorne described the idea in his book *Black Holes & Time Warps* as follows (see Figure 1).

> *"This random, probabilistic froth is the thing of which the singularity is made, and the froth is governed by the laws of quantum gravity. In the froth, space does not have any definite shape (that is, any definite curvature, or even any definite topology). Instead, space has various probabilities for this, that, or another curvature and topology. For example, inside the singularity there might be a 0.1 percent probability for the curvature and topology of space to have the form shown in (a), and a 0.4 percent probability for the form in (b), and a 0.02 percent probability for the form in (c), and so on."*

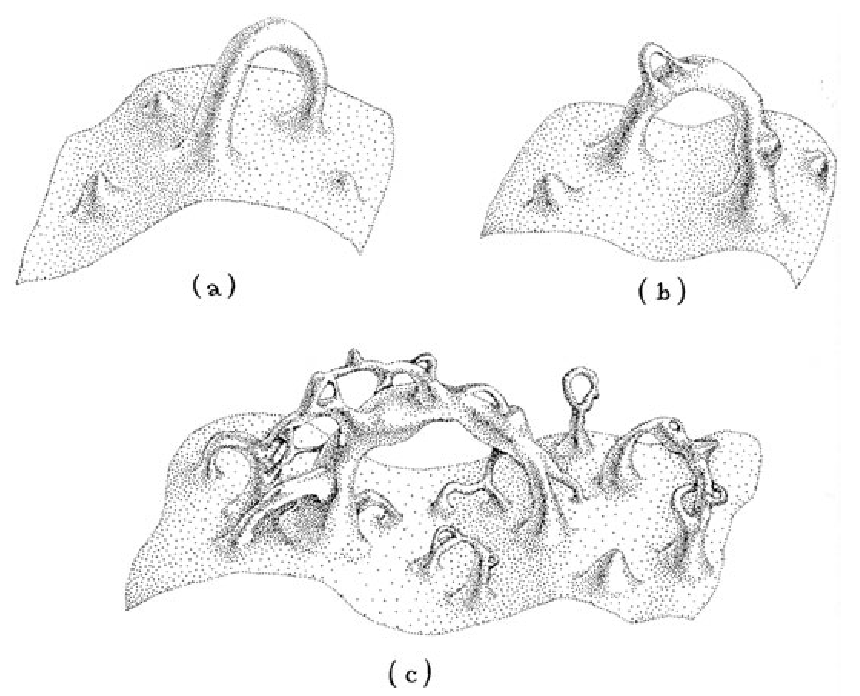


Figure 1. From Black Holes and Time Warps: Einstein's Outrageous Legacy, *by Kip S. Thorne (W. W. Norton & Company, Inc., 1994)*

In other words, perhaps we cannot say exactly what the properties of spacetime are in the immediate vicinity of a singularity, but perhaps we could characterize their distribution. By way of analogy, if we know that we are going to flip a fair coin a thousand times, we have no idea whether any particular flip will turn up heads or tails. But we can say that on average, we should expect about five hundred heads. Moreover, if we did the experiment many times we should expect a bell-curve shape (i.e., a normal distribution), so it is very unlikely, for example, that we would see more than six hundred heads.

To get a feel for a random space, here is an example that you can make at home. All you need is a deck of playing cards, some paper, scissors, and tape.

Make a mini-deck of twelve playing cards: ace, two, three, four, five, six, seven, eight, nine, ten, jack, queen. Cut four paper triangles. Label their sides A–Q (to correspond to your deck of cards) as in Figure 2. Shuffle the cards, then take the top two cards from the deck. Say the cards are five and seven: tape the side labeled five to the side labeled seven, keeping the printed side of each triangle side up. (This ensures that you end up with an orientable surface.) Again, take the top two cards from the deck, tape the corresponding triangle sides, and repeat until you have used all twelve cards and all twelve sides are taped. As you get toward the end, you might have to really bend up your paper. But after gluing six pairs, you are mathematically certain to have a surface. What is uncertain is which surface.

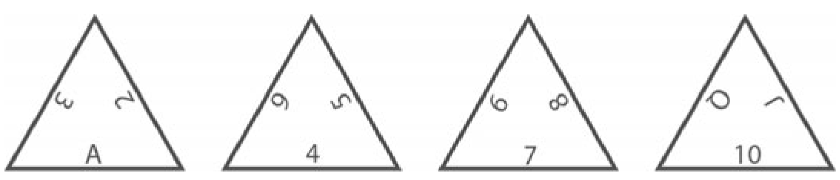


Figure 2

One might end up with a surface homeomorphic (i.e., continuously deformable) to a sphere or a torus. But one might also end up with two spheres or a sphere and a torus, so the surface need not be connected. However, if one did this with many triangles, it would be very likely that the surface would be connected and the main question would be its genus—i.e., how many "handles" or "holes" does it have. It turns out that if one glues together n triangles randomly in this way, one should expect a surface of genus roughly $n/4$, on average. (This is a theorem of Nicholas Pippenger and Kristin Schleich, and independently of Nathan Dunfield and William Thurston.)

It turns out that this relatively simple model of a random space already encodes a lot of physics as n tends to infinity, and in fact one of the motivations to study it is that it serves as a two-dimensional discrete analogue of quantum gravity. So random spaces provide a mathematical model of something of fundamental interest in theoretical physics and cosmology.

Random spaces also provide interesting models within mathematics itself, as well as useful constructions in theoretical computer science. To mathematicians and theoretical computer scientists, one of the important discoveries of the last fifty years is that random objects often have desirable, hard to come by otherwise, properties. There are many examples of this paradigm by now, but one of the first was in Ramsey theory.

John Wheeler suggested in the 1960s that inside a black hole the fabric of spacetime might be reduced to a kind of quantum foam. . . . Perhaps we cannot say exactly what the properties of spacetime are in the immediate vicinity of a singularity, but perhaps we could characterize their distribution.

A combinatorial fact: among any party of six people, there must be either three mutual acquaintances or three mutual nonacquaintances. This isn't necessarily true for five people. Let $R(n)$ denote the smallest number of people that guarantees that if you have a party of $R(n)$ people there are either n mutual acquaintances or n mutual non-acquaintances. So, taking the example above, $R(3)=6$. It is also known that $R(4)=18$, i.e., among any eighteen people, there must be either four mutual acquaintances or four mutual non-acquaintances. But $R(n)$ isn't known for any larger n.

Paul Erdős suggested that if advanced aliens threaten the Earth, telling us they will blow us up unless we tell them $R(5)$ within a year, we should put together all the best minds and use all our computer resources and see if we can figure it out. But if they ask for $R(6)$, he warned, we should probably attack first.

When mathematicians can't compute something exactly, we often look for bounds or estimates. In the case of Ramsey theory, lower bounds come from somehow arranging a party with not too many mutual acquaintances or nonacquaintances. As the number of people gets large, to describe this kind of structure explicitly gets unwieldy, and after decades of people thinking about it, no one really knows how to do it very well. The best lower bounds we know come from the simple strategy of assigning acquaintanceship randomly.

This is a surprising idea at first, but it turns out to be powerful in a variety of settings. In many problems one wants to maximize some quantity under certain constraints. If the constraints seem to force extremal examples to be spread around evenly, then choosing a random example often gives a good answer. This idea is the heart of the probabilistic method.

Ramsey theory is one of many examples where the probabilistic method has been applied to combinatorics. This method has also been applied in many other areas of mathematics, including metric geometry. For example, Jean Bourgain (Professor in the School of Mathematics) showed that every finite metric space could be embedded in Euclidean space with relatively low distortion—his method was to carefully choose a random embedding and show that it has low distortion with high probability.

Matthew Kahle, a Member (2010–11) in the School of Mathematics, is interested in various interactions of probability and statistical mechanics with topology, geometry, and combinatorics. Beginning in the fall, he will be an Assistant Professor at the Ohio State University.

The probabilistic method has many applications in theoretical computer science as well. For example, a network made by randomly joining pairs of computers will be fairly robust, in the sense that everything might still be connected even if a few cables fail. Such networks are called expanders, and expanders are a very active area of research. Although random methods construct expanders easily, until recently the only explicit examples came from deep number-theoretic considerations. Peter Sarnak and Avi Wigderson (Professors in the School) have made fundamental contributions to the theory of expanders.

There has been recent interest in finding higher-dimensional analogues of expanders, and it has now been shown that certain random spaces, similar to those described above, have expander-like properties. It seems likely that these new higher-dimensional expanders will find applications in spectral clustering and topological data analysis, in sparsification of cell complexes, and probably in as yet unforeseen ways as well. ■

Comets and Planets upon one another, and which will be apt to increase, till this System wants a Reformation.” Evidently Newton believed that the solar system was unstable, and that occasional divine intervention was required to restore the well-spaced, nearly circular planetary orbits that we observe today. According to the historian Michael Hoskin, in Newton’s world view “God demonstrated his continuing concern for his clockwork universe by entering into what we might describe as a permanent servicing contract” for the solar system.

Other mathematicians have also been seduced into philosophical speculation by the problem of the stability of the solar system. Quoting Hoskins again, Newton’s contemporary and rival Gottfried Leibniz “sneer[ed] at Newton’s conception, as being that of a God so incompetent as to be reduced to miracles in order to rescue his machinery from collapse.” A century later, the mathematician Pierre Simon Laplace was inspired by the success of celestial mechanics to make the famous comment that now encapsulates the concept of causal or Laplacian determinism: “An intelligence knowing all the forces acting in nature at a given instant, as well as the momentary positions of all things in the universe, would be able to comprehend in one single formula the motions of the largest bodies as well as the lightest atoms in the world, provided that its intellect were sufficiently powerful to subject all data to analysis; to it nothing would be uncertain, the future as well as the past would be present to its eyes. The perfection that the human mind has been able to give to astronomy affords but a feeble outline of such an intelligence.”

Many illustrious mathematicians and physicists have worked on this problem in the three centuries since Newton, including Vladimir Arnold, Boris Delaunay, Carl Friedrich Gauss, Andrei Kolmogorov, Joseph Lagrange, Laplace, Jürgen Moser, Henri Poincaré, Siméon Poisson, and others. Several “proofs” of stability have been announced in the course of these labors; these have all been based on approximations that are not completely accurate for our own solar system and thus do not prove its stability. Nevertheless, research on this problem has led to many new mathematical tools and insights (perturbation theory, the KAM theorem, etc.) and inspired the modern disciplines of nonlinear dynamics and chaos theory.

The long-term behavior of the solar system is also relevant to a variety of other issues. Particle accelerators such as the Large Hadron Collider must guide protons for over a hundred million orbits, a problem similar in several respects to maintaining the planets on stable orbits for the lifetime of the solar system. The delivery of meteorites to Earth from their birthplace in the asteroid belt is driven by the long-term evolution of asteroid orbits due to forces from Jupiter and other planets. The primary mechanism that drives climate change and ice ages on timescales of tens of thousands of years is the periodic variation in the Earth’s orbit due to forces from the other planets. The discovery of hundreds of extrasolar planetary systems in the last two decades raises the tantalizing possibility that some or all of their properties are determined by the requirement that these systems have been stable for billions of years. In a different arena, some astronomers argue that Robert Frost’s famous poem “Fire and Ice” was inspired by the possible fates of the Earth at the demise of the solar system.

Some astronomers argue that Robert Frost’s famous poem “Fire and Ice” was inspired by the possible fates of the Earth at the demise of the solar system.

ANDREA KANE

Scott Tremaine first came to the Institute for Advanced Study as a Member in 1978 and has been the Richard Black Professor in the School of Natural Sciences since 2007. He has made seminal contributions to understanding the formation and evolution of planetary systems, comets, black holes, star clusters, galaxies, and galaxy systems.

The most straightforward way to solve the problem of the stability of the solar system is to follow the planetary orbits for a few billion years on a computer. All of the planetary masses and their present orbits are known very accurately and the forces from other bodies—passing stars, the Galactic tidal field, comets, asteroids, planetary satellites, etc.—are either easy to incorporate or extremely small. There are two main challenges. The first is to devise numerical methods that can follow the motions of the planets with sufficient accuracy over a few billion orbits; this was solved by the development in the 1990s of symplectic integration algorithms, which preserve the geometrical structure of dynamical flows in multidimensional phase space and thereby provide much better long-term performance than general-purpose integrators. The second challenge was the overall processing time needed to follow planetary orbits for billions of years; this was solved by the exponential growth in speed of computing hardware that has persisted for the last five decades. At the present time, following planetary systems over billion-year intervals is difficult mostly because it is a *serial* problem—you have to follow the orbits from 2011 to 2020 before you can follow them from 2021 to 2030—whereas most of the computational speed gains of the last few years have been achieved by parallelization, the distributing of a computing problem among hundreds or thousands of processors that work simultaneously.

So what are the results? Most of the calculations agree that eight billion years from now, just before the Sun swallows the inner planets and incinerates the outer ones, all of the planets will still be in orbits very similar to their present ones. In this limited sense, the solar system is stable. However, a closer look at the orbit histories reveals that the story is more nuanced. After a few tens of millions of years, calculations using slightly different parameters (e.g., different planetary masses or initial positions within the small ranges allowed by current observations) or different numerical algorithms begin to diverge at an alarming rate. More precisely, the growth of small differences changes from linear to exponential: at early times, the differences in position at successive time intervals grow as 1 mm, 2 mm, 3 mm, etc., while at later times they grow as 1 mm, 2 mm, 4 mm, 8 mm, 16 mm, etc. This behavior is the signature of mathematical chaos, and implies that for practical purposes the positions of the planets are unpredictable further than about a hundred million years in the future because of their extreme sensitivity to initial conditions. As an example, shifting your pencil from one side of your desk to the other today could change the gravitational forces on Jupiter enough to shift its position from one side of the Sun to the other a billion years from now. The unpredictability of the solar system over very long times is of course ironic since this was the prototypical system that inspired Laplacian determinism.

Fortunately, most of this unpredictability is in the orbital phases of the planets, not the shapes and sizes of their orbits, so the chaotic nature of the solar system does not normally lead to collisions between planets. However, the presence of chaos implies that we can only study the long-term fate of the solar system in a statistical sense, by launching in our computers an armada of solar systems with slightly different parameters at the present time—typically, each planet is shifted by a random amount of about a millimeter—and following their evolution. When this is done, it turns out that in about 1 percent of these systems, Mercury’s orbit becomes sufficiently eccentric so that it collides with Venus before the death of the Sun. Thus, the answer to the question of the stability of the solar system—more precisely, will all the planets survive until the death of the Sun—is neither “yes” nor “no” but “yes, with 99 percent probability.”

Shifting your pencil from one side of your desk to the other today could change the gravitational forces on Jupiter enough to shift its position from one side of the Sun to the other a billion years from now.

There remain two intriguing facts that lead to a plausible speculation. First, the *future time* required for the loss of Mercury is rather similar, within a factor of five or so, to the *past time* at which the solar system was born. Second, the solar system is nearly “full,” in the sense that there are few places where we could insert an additional planet without causing immediate instability. Both of these facts are explained naturally if the solar system began with more planets, in a configuration that was unstable on timescales much smaller than its current age. As time passed, the system lost more and more planets and thereby gradually self-organized into a more and more stable state. In this process, the time required to lose the next planet would quite naturally be a few times the current age. There would be few fossil traces of these lost siblings of the Earth. ■

other D-branes, so the number of configurations becomes much smaller.

A large number of D-branes is heavy enough to warp the spacetime around them and to produce a black hole. In order to produce a black hole with some temperature it is necessary to excite these N^2 degrees of freedom. This leads to a precise microscopic accounting for the entropy of the black holes, as shown by Andrew Strominger and Cumrun Vafa (both former Members of IAS). These N^2 degrees of freedom produce a highly entangled state that cannot be described in terms of the motion of the individual particles. However, it can be described very precisely in terms of the gauge theory of the N x N matrices. This gauge theory is not particularly different from the ones we use to describe the strong force in nature. Some details are different. However, in some very important respects it is the same. First, it obeys the usual rules of quantum mechanics. Second, it lives on a fixed spacetime—in this case, the point in spacetime where the branes are sitting.

Actually, this leads us into an apparent contradiction. On the one hand, we said that we can describe the branes in terms of a gauge theory living at a spatial point. On the other hand, we said that the branes form a black hole, which has a non-zero horizon size.

In fact, in string theory, these two descriptions are viewed as equivalent. The gauge theory is describing the whole region around the black hole. If we view the black hole from very far away, it looks like a point—that is why the matrices live at a point. On the other hand, the matrices also give rise to the whole spacetime region around the horizon of the black hole. This is the gauge/gravity correspondence proposed by myself and Edward Witten (at IAS) and Steven Gubser, Igor Klebanov, and Alexander Polyakov (at Princeton University).

These theoretical developments were made with the goal of showing that black holes behave like ordinary quantum mechanical objects. More recently, the same relation is being explored in order to model strongly interacting quantum systems via black holes.

The gauge theory gives a precise description of the black hole and its surrounding geometry. It is described in terms of a perfectly ordinary quantum mechanical system. This explains its entropy. It also gives a completely quantum mechanical description of the black hole and the spacetime around the black hole. This description is sometimes called "holographic" because the whole spacetime emerges dynamically from a quantum mechanical description that lives in a smaller number of dimensions. (An ordinary hologram is a two-dimensional surface that produces a three-dimensional image when it is illuminated.)

Recommended reading: *The Black Hole War* by Leonard Susskind (Little, Brown and Company, 2008)

Going back to the analogy of the group of people and the pattern of likes and dislikes, the idea is that the whole spacetime is encoded in the pattern of likes and dislikes among the various people. A spacetime ripple is a change in that pattern. The "gauge theory" is a simple dynamical law that says how this pattern changes.

This description has been explored actively here at the Institute and elsewhere. It is best understood in very special configurations in string theory. However, similar descriptions are expected to be valid for black holes in general. These theoretical developments were made with the goal of showing that black holes behave like ordinary quantum mechanical objects. More recently, the same relation is being explored in order to model strongly interacting quantum systems via black holes. Thus, in some sense, black holes have become a source of information, rather than the sinks they were feared to be! ■

Trade and Geography in the Economic Origins and Spread of Islam

BY STELIOS MICHALOPOULOS

Karl Marx linked the structure of production to the formation of institutions. According to Marx, religion is like any other social institution in that it is dependent upon the economic realities of a given society, i.e., it is an outcome of its productive forces. In contrast, Max Weber highlighted the independent effect of religious affiliation on economic behavior. Weaving these insights together, my research with Alireza Naghavi and Giovanni Prarolo of the University of Bologna proposes that geography and trade opportunities forged the Islamic economic doctrine, which in turn influenced the economic performance of the Muslim world in the preindustrial era. Since Islam emerged in the Arabian peninsula when land dictated productive decisions, the arrangement of Islamic institutions had to be compatible with the conflicting interests of groups residing along regions characterized by a highly unequal distribution of agricultural potential.

In particular, we argue that the unequal distribution of land endowments conferred differential gains from trade across regions. In such an environment, it was mutually beneficial to establish an economic system that dictated both static and dynamic income redistribution. The latter was implemented by enforcing an equitable inheritance system, increasing the costs of physical capital accumulation, and rendering investments in public goods, through religious endowments, increasingly attractive. These Islamic economic principles allowed Muslim lands to flourish in the preindustrial world but limited the potential for growth in the eve of large-scale shipping trade and industrialization. In a stage of development when land attributes determine productive capabilities, regional agricultural suitability plays a fundamental role in shaping the potential of a region to produce a surplus and thus engage in and profit from trade. Based on this idea, we combined detailed data on the distribution of regional land quality and proximity to pre-Islamic trade routes with information on Muslim adherence across local populations.

CLIFF MOORE

Stelios Michalopoulos, the Deutsche Bank Member (2010–11) in the School of Social Science, is Assistant Professor of Economics at Tufts University.

To mitigate concerns related to the endogeneity of contemporary political boundaries, we arbitrarily divided the world into geographic entities, called virtual countries, and found that Muslim populations dominated more unequally endowed places closer to preindustrial trade routes. Naturally, modern states have affected religious affiliations via state-sponsored religion. Nevertheless, the above pattern remains robust when we account for these state-specific histories.

As part of our study, we assembled information on the traditional location of ethnic groups. Consistent with the hypothesis that Islamic economic principles provided an attractive social contract for populations residing along productively unequal regions, we found that Muslim adherence increased with the degree of geographic inequality. Islam spread successfully among groups historically located in agriculturally poor regions featuring few pockets of fertile land and in countries characterized by unequal land endowments. It was in these areas that the Islamic institutional arrangement proved appealing to the indigenous populations.

Islam spread both via conquests and via the peaceful adoption of the doctrine. Because our theory focuses on the economic conditions conducive to the voluntary adoption of Islam, we concentrated on regions outside the Muslim empires. Doing so allowed us to single out the role of geography and trade and mitigate concerns related to the process of conversion within Muslim empires arising from coercion, Arab migration, and differential taxation.

The acceptance of Islam in most of Inner Asia, Southeast Asia, and sub-Saharan Africa is well known to have occurred through contacts with merchants. The independent role of proximity to pre-Islamic trade routes, as a means of gaining access to the Muslim trading network, was also an important contributor. The location of Indonesia along highly lucrative commercial routes, for example, precipitated the spread of Islam since the eleventh century despite a fairly equally distributed regional agricultural potential.

We do not suggest that Muslim economic principles are unique to the Islamic religion. Similar principles of wealth redistribution may be found in other Abrahamic religions at certain points in history, but in the course of time they became less focal. We propose that these principles emerged and persisted in Islam because of a geography characterized by highly unequal agricultural endowments, which shaped the economic aspects of the Islamic religious doctrine. The fact that Muslim merchants dominated African and Eurasian trade routes between the seventh and fifteenth centuries implies that the indigenous populations in Asia and Africa were primarily exposed to the Muslim doctrine. Even if one were to take the view that Christianity and Islam are doctrinally close substitutes, historically the effective choice that tribal areas outside Muslim empires faced was either to become Muslim or to retain their tribal religions. Along these lines we find that local, tribal religions persisted in territories with relatively equal endowments, whereas Muslim adherence increased systematically in territories close to trade routes featuring unequal land endowments. ■

Albert O. Hirschman's Early Institute Years

BY JEREMY ADELMAN

Albert O. Hirschman became a permanent Faculty member of the Institute in 1974, moving from Harvard's economics department to join Clifford Geertz in the creation of the School of Social Science. By then, Hirschman was not just famous for his writings about economic development and his analyses of Latin American political economies. His *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States* (Harvard University Press, 1970) had made him one of the country's renowned social scientists.

Behind the scenes, however, his concerns were shifting; he was, he said, "retreating" into history and the study of the intellectual foundations of political economy. Retreat did not sever his interest in the present. If anything, it was the present that gnawed at him, especially in Latin America. In late summer 1973, Hirschman became the Chair of the Social Science Research Council Joint Committee for Latin American Studies. Ten days later, he learned of the violent overthrow of Chile's socialist President, Salvador Allende, whom Hirschman had met and admired as an example of a "reform-monger," a type he celebrated in *Journeys Toward Progress* (Twentieth Century Fund, 1963), his epic of Latin America's hopeful 1960s. Allende's death and the disappearance of friends and former students, indeed the wave of authoritarian regimes sweeping the region, shattered the optimism that had buoyed his thinking.

If, by 1976, Hirschman's bias for hope was fraying, it was hard for the outer world to see. As Hirschman was planning a trip to Latin America, McGeorge Bundy, President of the Ford Foundation, asked Hirschman and Geertz to sit down and converse about the theme "the hungry, crowded, competitive world." The idea was to raise some critical perspectives that would guide the foundation's thinking about their funding priorities for the future. The very topic of the gathering conveyed the prevailing mood. Hirschman was determined to challenge it by, as he told Bundy, showing "that I am less of a mindless optimist than people (and sometimes my closest colleagues and friends) tend to think." The conversation began with its dark tone; Hirschman immediately resisted it with a reminder to put social scientific analysis into a broader historic context. The naive 1950s believed "all good things go together": increase GDP and get democracy; free people, and they will invest. "It was a simplistic model," he recalled. "But now we have come in a sense to the inverse idea, that all bad things go together": growth is bunk; human rights exist to be trampled on. But this "dismal diagnosis," according to Hirschman, was "probably just as wrong as the earlier one, and I'm also a little bit suspicious of where it leads us." Geertz, who knew Hirschman as well as anyone, and was one of the friends who poked fun at his resilient hopefulness, chimed in: "Albert always wants to look on the bright side." Geertz was not the first to point out that for Hirschman "truth lies not at the extremes but in the middle."

Hirschman believed that the divide between hope and hopelessness, optimism and pessimism, was a false one. It was not a matter of whether the overall story was bleak or uplifting, but how it was told, for the epic passage of social change was riddled with chance and choice. He wanted to get at social scientists' mindsets, why they persisted "in thinking of having only one thing happen, and everything else will coalesce around it, and we'll come out all right." Why, asked Hirschman, do "we only have one 'new key' at a time?"

His solution was not, however, to exhort or to "voice," but rather a kind of "exit," a "withdrawal to history"—"to dwell for a while among the political philosophers and political economists of the seventeenth and eighteenth centuries" in search of early patterns of thinking about capitalism and democracy.

A phrase from Montesquieu's *Spirit of the Laws* was filed away in his archive of favorite quotes: "It is fortunate for men to be in a situation where, though their passions may prompt them to be wicked, they have nevertheless an interest in not being so." The phrase would, fittingly, be the epigraph for the manuscript *The Passions and the Interests: Political Arguments for Capitalism Before its Triumph* (Princeton University Press, 1977). In it was nestled the foundational paradox that motivated Hirschman. Marxists and romantics alike criticized capitalism for its lack of moral compass, for having narrowed individual drives to base motives, and they denounced the system for realizing precisely what it was originally hoped would happen, presenting a choice to men between the "wicked" and an "interest in not being so." Hirschman discovered that a war was being waged over the very concept of human nature; for several centuries, Hirschman noted, "man was widely viewed as the stage on which fierce and unpredictable battles were fought between reason and passion or, later, among the various passions."

MARTIN ARIAS

Albert Hirschman came to the Institute in 1974 and helped create the School of Social Science.

Hirschman believed that the divide between hope and hopelessness, optimism and pessimism, was a false one. It was not a matter of whether the overall story was bleak or uplifting, but how it was told, for the epic passage of social change was riddled with chance and choice.

Moving to the Institute brought Hirschman face to face with new currents in intellectual history. The history of ideas was, in some respects, a polar extreme to development studies and its concerns with roads, inflation, and agrarian reform. For Hirschman, however, it was not such a stretch to see the links between these universes; as we know from his conversations with Latin American colleagues, he was always alert to the ways in which ideologies and intellectuals shaped the thinking of policymakers who fashioned the spectrum of peoples' choices. Now it was Machiavelli, Montesquieu, and Adam Smith who were conversing with him about the same themes. Mediating his retreat into early ideological formulae was a shift in intellectual history from the study of the inherent significance of classic thought to the meaning of a treatise derived from a reconstruction of the political idiom of when and where it was written. A key figure was Quentin Skinner, who himself had moved from England to take up a sojourn at the Institute, first in the School of Historical Studies, and then in Social Science until his return to Cambridge.

Notes of conversations and readings shared with Skinner and others were scribbled on Hirschman's ubiquitous yellow pads. When the first draft of *The Passions and the Interests* was complete, he shared it with friends at the Institute. To Skinner, Hirschman's arrival at Adam Smith and economics was less a concern than a departure with Machiavelli and politics, the beginnings of an intellectual arc to which the manuscript was devoted. Skinner spent more time teasing apart nuances that Hirschman—in his brevity—glossed over (for instance, the difference between honor and glory in *The Prince*, which Hirschman lumped together, but which Skinner felt represented quite different ideals in the Renaissance; perhaps Calvin would be a better example than Hobbes as an illustration of someone who imagined the state as a repressor of man's passions?). Skinner also directed Hirschman to an alternative fount for thinking about the ideal of active citizenship and commerce in Machiavelli, not of *The Prince*, which is where Hirschman had started out, but in the *Discorsi*, where Hirschman went after Skinner pointed it out.

In the examination of discourses about market life and behavior by seventeenth- and eighteenth-century political economists, Hirschman focused on passions-oriented anxiety and the use of language to control and channel socially useful pursuits. At the core of *The Passions and the Interests* was an observation about how verbal messages became absorbed or "imposed themselves"—how words themselves had agency. To be effective, interest-propelled activity by governments and individuals required a light hand, invisible or not. This is a reason why, as Skinner pointed out to Hirschman, the verb "to meddle" acquired a derogatory currency over the course of the eighteenth century.

The Passions and the Interests was itself an argument for a historic middle ground between nostalgia for lost passions and a celebration of "the love of lucre." Hirschman did not want to celebrate a model of acquisitive citizens; nor did he think restoring the passions was an especially good idea either. He was a modernist. His was a vision, projected through the prism of earlier discourses, of polite, civic-minded people going about their business in ways that enabled self-interest and the common good to coexist in the same sentence, a *harmonielehren* that could be both realistic and hopeful. It was a delicate balancing act, one that Hirschman claimed had served a normative purpose of restraining impassioned rulers and the ruled, a purpose that had been degraded by what would subsequently happen to the language of capitalism—and at its extremes, by despots like Pinochet who claimed to be its last defense.

While the book was greeted with rave reviews, and the reception and attention delighted Hirschman, at a deeper level the book only magnified the gap between his understanding of the economy and prevailing trends in the economy. To make matters worse, though he had retreated to earlier centuries, the crisis of the 1970s was hard upon him. Geertz and Hirschman redirected the concerns of the School of Social Science away from the strong focus on developing societies to address, starting in 1977, advanced industrial societies. For the first time, European social scientists like Alessandro Pizzorno and Claus Offe came to the School. Also, America's leading liberal philosopher, John Rawls, joined the assembly for one semester. The group decided to meet Monday evenings in people's homes for informal discussions that soon swelled, nurtured by the growing crisis of the welfare state, spreading strikes, and the meltdown of New

SERGE J-F. LEVY

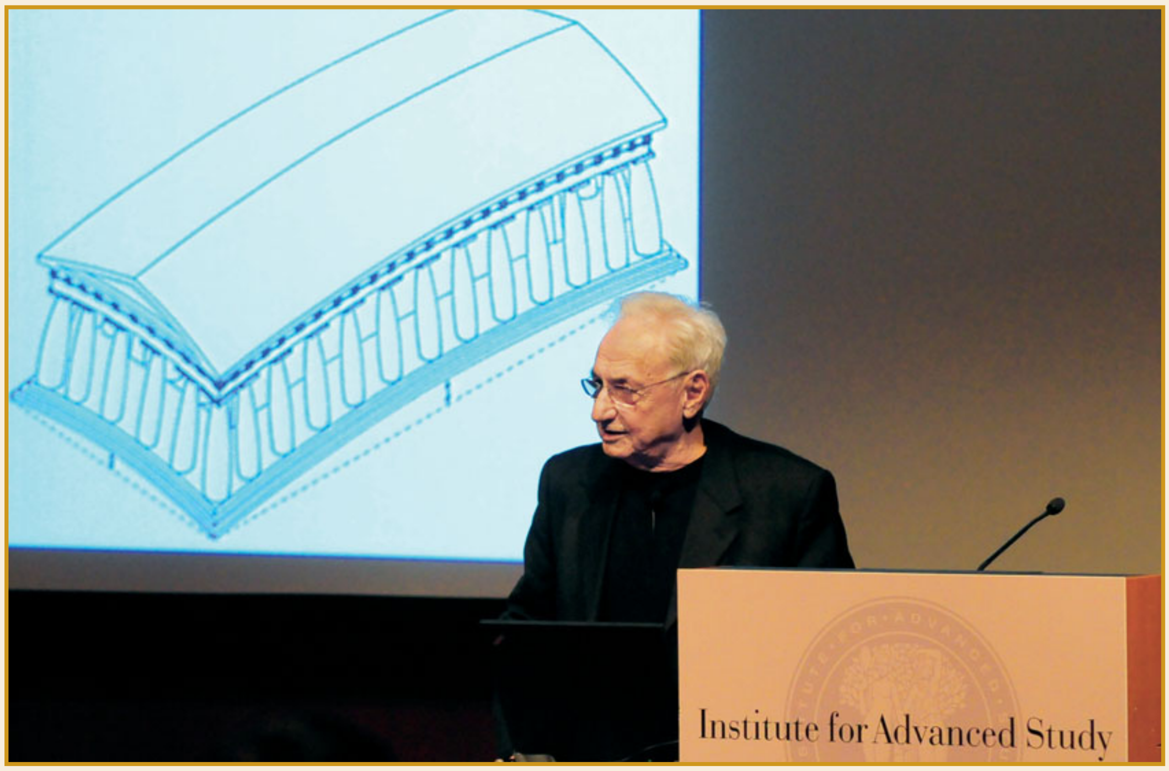
John F. Nash Jr. reads at teatime in this photograph from a book about the Institute forthcoming in fall 2011.

PRE-ORDER REMINDER

A Community of Scholars: Impressions of the Institute for Advanced Study

In fall 2011, Princeton University Press will publish *A Community of Scholars: Impressions of the Institute for Advanced Study with photographs by Serge J-F. Levy*, a collection of essays and photographs that captures academic and social life at the Institute. The volume, with an introduction by Peter Goddard, includes photographs taken by Levy during the 2009–10 academic year and personal reflections by Michael Atiyah, Chantal David, Freeman Dyson, Jane F. Fulcher, Barbara Kowalzig, Wolf Lepenies, Paul Moravec, Joan Wallach Scott, and David H. Weinberg. To pre-order copies of the book for $19.95 (a 20 percent discount off the $24.95 cover price), please call (800) 777-4726. The ISBN number is 978-0-691-15136-6 and the offer code is P04657. The pre-order offer is good until September 30, 2011. ■

Frank Gehry: Thinking Out Loud



BENTLEY DREZNER

The architect Frank O. Gehry gave a public lecture, "Thinking Out Loud," at the Institute in March, in which he spoke about the origins and influences of his work. Gehry was a Visitor in the School of Natural Sciences' Simons Center for Systems Biology in the spring. He participated in a series of programs at the Institute that explored the relationship between architecture and science, specifically the process of creativity and research in the two fields. Gehry's visit was organized by Arnold Levine, Professor in the School of Natural Sciences, and Irving Lavin, Professor Emeritus in the School of Historical Studies.

York City's finances to address the hot topic of the "governability of modern democracy." Rawls and Offe led an evening's discussion of Habermas's *Legitimation Crisis*; another evening Hirschman and Pizzorno led the discussion of Mancur Olson's *The Logic of Collective Action*.

Having diagrammed his views of original arguments for capitalism *before* its triumph, Hirschman sat down to settle scores with Olson's highly influential 1965 work, a near-biblical argument for a model of capitalism *after* its triumph. More than any other, Olson's book nurtured the emerging field of institutional economics and popularized coinages like "collective action problems" and "free-riders." At the heart of Olson's work was an argument that modern societies create incentive systems that induce individuals to invest their energies in private goods, but thwart the pooling of these efforts collectively to create public goods. Moreover, these propensities were bound by an immutable "logic." Hirschman felt compelled to position himself before triumphal discourses of the 1970s, and he took advantage of one evening's discussion at Geertz's house to take Olson as Exhibit A for what he would spend the next fifteen years trying to expose: the rhetoric and politics of the ideological underpinnings of the Right.

It was a heated evening discussion. Geertz found the whole Olsonian proposition absurd and huffed in objection to free-riding. Hirschman labored to explain principles he disavowed. Rawls retreated into silence. And Herbert Gintis, a visitor from the University of Massachusetts, insisted that there had to be "an answer" to the Olsonian formula. In the end, Hirschman managed to conclude with one of his favorite quotes from Rousseau: "What makes for human misery is the contradiction between man and citizen; make him one and you will make him as happy as he can be; give him wholly to the state or leave him wholly to himself; but if you divide his heart you will tear it apart." The discussion that evening opened a thickening file, a quest for an "answer" to the vexing question: Was there a way to imagine modern societies consisting of citizens and consumers who were not forced, or asked, to divide their hearts?

Hirschman's concern to reconcile the widening gulf between public citizenry and private consumers was also the result of his irritation with "singular" ways of thinking and the pernicious ways in which singular thinking was shaping world events. In the autumn of 1979, American television screens were flooded with scenes from Tehran, where radical students had seized the U.S. embassy. That Thanksgiving, Albert and his wife Sarah invited some friends over, Roberto Schwarz and Carlos Fuentes and their wives, for goose (the Hirschmans' favorite fowl). They were riveted to the television and worried about the government's response with the elections looming. The images of crowds "seemingly so full of hatred against the United States," was utterly depressing from Hirschman's perspective. It was not just the hatred on display in Iran, it was the sense of "unity" in America, and portents of a "turn inward," that prompted him to observe, "This may well be the end of public interest in development in the Third World—so, from the point of view of my interests, I also see it as the end of an epoch."

Several weeks later, he walked before the podium in Dodds Auditorium at Princeton University to deliver the Janeway Lectures to large crowds of students and faculty on the theme of "Private and Public Happiness: Pursuits and Disappointments." For Hirschman there was no basic choice between the two types of happiness; it was not "or" that conjoined public to private. If there was a choice, the point of the lectures was to argue that people were always choosing depending on their moods and inclinations, and it was this activity that Hirschman wanted to draw out. Hirschman's Janeway Lectures addressed experiences and emotional responses to them—anger at educational institutions, self-incrimination for buying a large house and regretting it ("buyer's remorse"), and the ever disappointing "driving experience," which, far from yielding to the lyrical joy ride, more often plunged the BMW-driving pleasure-seeker into traffic jams and car payments. Pursuits of happiness wherever it was being dispensed left trails of disappointment.

In contrast to Olson's "logic," Hirschman presented a "dialectic" that unfolds within the self, a self comprised of a complex amalgam of drives. Hirschman's pendular dialectic was the theme of *Shifting Involvements: Private Interest and Public Action* (Princeton University Press, 1982), in which he stuck his neck out to formulate an alternative to the gathering political and intellectual orthodoxy. "I have rarely felt so uncertain about a product of mine," he told his daughter Katia. "Perhaps this is because, as I say in the preface, what I have written is less a work of social science, than the conceptual outline of one or several novels." Indeed, the preface suggests that there is much more of Hirschman's personal philosophy and life story stirred into the prose. It threatened to become a bildungsroman "with, as always in novels, a number of autobiographical touches mixed in here and there."

If there were autobiographical touches, they were not so easy to see. Certainly, no reviewer picked them out, though many did pick on the book as a disappointing one. Compared to earlier books this one was a flop. Nowadays, it is often overshadowed. But one might read *Shifting Involvements* as a resistance against ideas of triumphalism of any one side and defeatism of any other. To both he insisted there was always more choice, there were always more possibilities, always hope. ■

Jeremy Adelman, a Member (2001–02) in the School of Historical Studies, is the Walter Samuel Carpenter III Professor in Spanish Civilization and Culture at Princeton University, where he is currently the Director of the Council for International Teaching and Research. At present, he is completing a biography of Albert O. Hirschman, Professor Emeritus in the School of Social Science.

The Institute Lands: Cultivating a True Academic Village

From its earliest days, the Institute recognized the importance of land and location to its ultimate success. In considering the acquisition of land, the founders focused on locating the Institute in an area with ready access to a world-class library, proximity to other institutions of learning, and the opportunity for further expansion to promote institutional atmosphere and spirit. After much discussion, the Buildings and Grounds Committee determined that the Princeton vicinity would be ideal because of the opportunity for social and scholarly contacts and access to university surroundings.

Oswald Veblen, a Norwegian-American topologist who was a faculty member at Princeton University for twenty-seven years before becoming the first member of the Institute Faculty (1932–60), was instrumental in the Institute's acquisition of land in Princeton. When he first learned of the Institute in an announcement in the *New York Times* in 1930, Veblen wrote to the Founding Director, Abraham Flexner, suggesting that the new Institute should be located in the borough or township of Princeton "so that you could use some of the facilities of the University and we could have the benefit of your presence."

Flexner took Veblen's suggestion under consideration, and in October 1932, he wrote: "I have it in mind now to go down to Princeton quietly for a week or so for the purpose of familiarizing myself with the general situation, for that may help us in our final choice. I should like to be away from undergraduate activities and close to graduate activities."

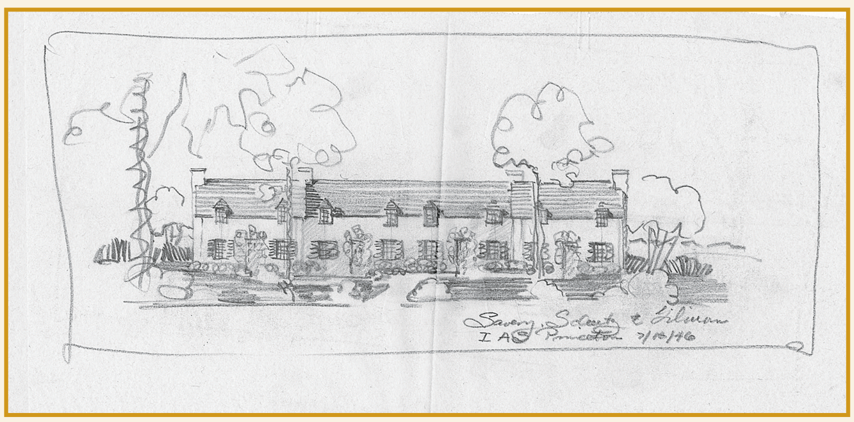
In 1934, Veblen wrote to Flexner, stressing the importance of purchasing more land than might be deemed necessary and saying, "There is no educational institution in the United States which has not in the beginning made the mistake of acquiring too little rather than too much land."

It took more than five years from the Institute's founding for a decision to be made to locate the Institute on Olden Farm, near a Quaker meeting house on a settlement known as Stony Brook in Princeton. Flexner was initially opposed to the purchase of the property, saying, "I am quite clear that at this moment we have neither the time nor the money to bother about the Olden Manor and the Olden Farm . . . . It is my conviction that we will never have any academic buildings on the farm, and I have such grave doubts as to the use of the Manor for social purposes . . . ."

By 1936, 256 acres had been purchased for a total of $290,000, including the two-hundred-acre Olden Farm, with Olden Manor—the former home of William Olden and the residence of the Institute's Director since 1940—as well as a large, working barn. Veblen continued to explore local land for sale, and over the next few years he bargained with local landowners to help the Institute acquire a total of 610 acres, including the Institute Woods.

In 1936, the Buildings and Grounds Committee reported to the Board of Trustees that they had purchased a "substantial acreage in Princeton" adequate for any immediate and future needs. Nine years later, with the purchase of the Maxwell estate under Frank Aydelotte, Director of the Institute from 1939 to 1947, the Institute's land acquisition was completed. Aydelotte wrote to Herbert H. Maass, an Institute Trustee: "I think this is the psychological moment to close the deal. With this tract in our possession, the Institute will have one of the finest pieces of educational real estate that I know of anywhere."

DAVID KENNEDY



INSTITUTE FOR ADVANCED STUDY

Top, an aerial view of the IAS campus taken in 2005 by David Kennedy, a former Member (1986–87, 2004) and Visitor (2005) in the School of Historical Studies. Bottom, a 1946 drawing of proposed housing.

The Village Green

Today, many of the Institute's permanent Faculty and the Members and their families who visit the Institute each year live on or very close to campus, creating a sense of community that fosters serendipitous interactions and incidental discussions from which important insights often follow. In the development of its campus, members of the Institute's Buildings and Grounds Committee made it a priority to provide local housing for the Members and a large proportion of the Faculty to allow for the cultivation of ideas in a true academic village.

By the end of 1936, there existed throughout Princeton a significant shortage of available housing, and what little was available was also very expensive. The Institute turned to Swarthmore College and Princeton University to examine how they used part of their endowment to build rental housing for faculty. In early 1937, the Institute's Board determined that it was essential that everything possible be done to assist Faculty in acquiring nearby homes. A plan was devised by Winfield Riefler, Professor (1935–49) in the School of Economics and Politics (it became part of the School of Historical Studies in 1949), that involved the Institute's sale of land that was not essential for its main campus to those Faculty who wished to erect homes for their own occupancy. The Institute hired an architectural firm to review and identify sites on Olden Farm for the purpose of providing housing to Faculty. Subsequently, Battle Road Circle was designed and built, with roads and Faculty housing completed before Fuld Hall construction was finished. Over the years, the Institute has continued to develop its land mindful of the need to be able to provide adequate housing for its Faculty. In the near future, the Institute plans to build additional Faculty homes on its campus so as to preserve its fundamental character as a residential institution.

As time went by and the Institute grew, the need for designated Member housing located close to the Institute became apparent. In 1941, the Board of Trustees began investigating the option of building apartments for visiting scholars. The urgency of the need called for quick action. Unfortunately, building during wartime was impossible, and the Institute looked into the possibility of prefabricated housing. It took until 1946 before firm plans were set to erect dwellings consisting of four six-family units and seven two-family units between Cook and Goodman Roads. Julian Bigelow, Member in the Electronic Computer Project and later the Schools of Mathematics and Natural Sciences, offered to negotiate on behalf of the Institute with the Federal Public Housing Authority for surplus government housing that could be made available to educational institutions. Aydelotte, who filed the application for the housing, stressed the excellent quality of these buildings, which were not prefabricated but individually constructed at Mineville, New York, on the edge of the Adirondacks. With Bigelow's guidance, the Institute was able to purchase eleven buildings containing thirty-eight apartments of two and three bedrooms each. These apartments were substantially built, with hardwood floors, insulation, storm windows, fly screens, clothes lines, and garbage pails, lacking only electric refrigerators. With the assistance of an Institute Trustee, Lessing J. Rosenwald, who was Chairman of Sears, Roebuck and Co., the Institute was able to secure thirty-eight electric refrigerators from Sears. The housing units were "panelized" for transportation to Princeton, and they were occupied in early 1947.

However, by 1957 the limitations of the Member housing, heated by coal stoves that required constant stoking during the long New Jersey winters, was apparent to J. Robert Oppenheimer, Director of the Institute from 1947 to 1966. He hired the noted architect Marcel Breuer to design a complex of Member housing more appropriate to the community. According to an article in *Architectural Record* in March 1968, one of the important factors in planning the arrangement of the plot was the provision of an environment and facilities to foster the community spirit of the Membership. The focus was on the "village green," with the natural configuration and character of the land being maintained and the placement of buildings fit to the existing contours of the land. Open House Day was held on October 11, 1957, offering tours of the new Breuer apartments to the Princeton community. The Breuer design was so successful that the Institute found only very minor changes were needed when the housing was expanded in 1968, and again in 1973 and 2000.

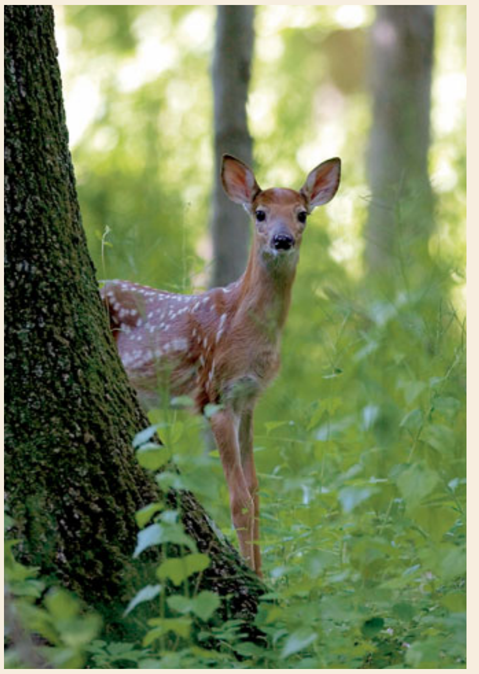
A Refuge for Ideas and Wildlife

The Institute was conceived as a refuge for ideas, but it also serves as a refuge for wildlife. Veblen, who arrived in Princeton in 1905, loved the outdoors and played an instrumental role in acquiring the Institute Woods, now a 589-acre nature reserve that forms a key link in a network of green spaces in central New Jersey. In addition to serving on the Buildings and Grounds Committee, Veblen "organized what was called a wood-chopping group," according to Deane Montgomery, the late Professor (1951–92) in the School of Mathematics. "They used to go out and clear some of the paths that nobody had cleared at that time." Veblen was joined by many notable figures, including the distinguished physicist Paul Dirac, a frequent Member in the School of Natural Sciences between 1934 and 1963. "No one will ever know how many problems in mathematics, physics, history, astronomy, economics, political science, social science, computing, and biology have been brought one step closer to a solution by a shared conversation or a solitary walk in the Institute Woods," wrote George Dyson, a former Director's Visitor (2002–03) and son of Freeman Dyson, Professor Emeritus in the School of Natural Sciences, in the *Institute Letter* (Winter 2007).

The Institute's preservation of the woods, farmlands, and surrounding lands was undertaken with the leadership of the late Princeton resident Frank E. Taplin Jr., Institute Trustee and Trustee Emeritus for more than thirty years. The preservation was done as part of the 1997 Greenacres easement that unified nearby preserved lands, further protecting a fifty-six-mile-long greenway network through central New Jersey that is critical for the feeding and nesting of two hundred species of birds on the Atlantic flyway. With the assistance of dedicated donors, the Institute funds the maintenance of the Institute Woods and farmlands, which are utilized year-round by the public. In 2008, local residents Addie and Harold Broitman, Friends of the Institute since 1994, made a generous gift through the Broitman Foundation to support trail maintenance for the benefit of all who use the Woods.

Over the decades the Institute has provided land to help establish the nearby Princeton Battlefield State Park. In the early 1950s, the Institute leased land to the State to increase the size of the park, and in 1973, it conveyed thirty-two acres to the State to enlarge the size of the park by 60 percent. In 1959, the Institute donated the former Mercer Manor monumental portico that now stands on the Battlefield north of Mercer Road, commemorating the common grave of unknown American and British soldiers killed in the Battle of Princeton in 1777.

From its earliest days, the Institute has sought to cultivate a sense of community and curiosity that extends beyond its campus. Every year, the Institute offers free lectures and concerts to the public, who may also meander the same grounds that have provided a place for contemplation and discussion for generations of Institute scholars from Veblen and Einstein onward. ■



VLADIMIR VOEVODSKY

An Institute Woods Exhibition

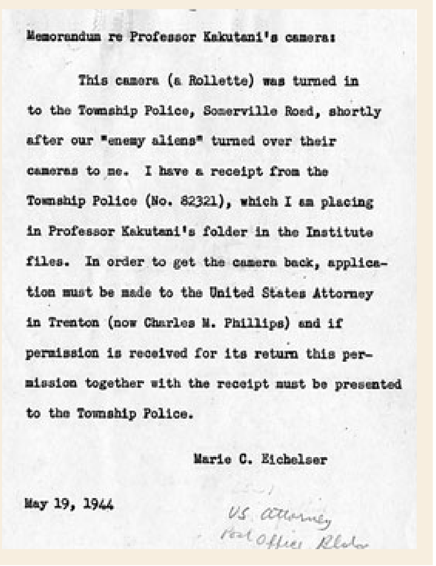
A selection of photographs taken in the Institute Woods by Vladimir Voevodsky, Professor in the School of Mathematics, will be on display October 24–December 2 at the Johnson Education Center of D&R Greenway Land Trust. The photographs will be part of an exhibit of art and photography highlighting lands protected by D&R Greenway in the Princeton area. The Institute Woods, which comprise 589 acres of woods, wetlands, and farmland, have been permanently conserved since 1997. An opening reception for the exhibit will be held November 6 from 4 to 6 p.m. at the Johnson Education Center, located at 1 Preservation Place, Princeton, New Jersey. For more information, visit www.drgreenway.org or call (609) 924-4646.

Security Versus Civil Liberties and Human Rights

BY DANIELA L. CAGLIOTI

The security of a nation and the safety of its population versus the protection of constitutional liberties and human rights is a quandary that arose in the aftermath of 9/11, but it is not novel to the twenty-first century. Discrimination between citizens and aliens, ethnicization of citizenship, the use of emergency powers in order to deal with the enemy and bypass the constitution, and the tendency to shift guilt and responsibility from the individual to a collective category (e.g., the Jews, the Muslims, etc.) are practices rooted in the past.

In my research, I have been looking at how governments and armies during World War I began to deal with these issues. The governments of almost all the nations that took part in World War I issued decrees and implemented measures against civilians of enemy nationalities who at the outbreak of the war were within their territory. Persons with ties to an enemy country were presumed to be more loyal to their origins than to the countries in which they worked and lived. German and Austro-Hungarian subjects living in France, Britain, or Russia, and later in all the countries that joined the Allies, and British, French, and Russian citizens who lived in Germany or in the Habsburg Empire, and then in Turkey or Bulgaria, were recast as dangerous, sometimes extremely dangerous, internal enemies.



Memorandum re Professor Kakutani's camera:

This camera (a Rollette) was turned in to the Township Police, Somerville Road, shortly after our "enemy aliens" turned over their cameras to me. I have a receipt from the Township Police (No. 82321), which I am placing in Professor Kakutani's folder in the Institute files. In order to get the camera back, application must be made to the United States Attorney in Trenton (now Charles M. Phillips) and if permission is received for its return this permission together with the receipt must be presented to the Township Police.

Marie C. Eichelser

May 19, 1944

INSTITUTE FOR ADVANCED STUDY

A memo from the Institute archives explaining the process of reclaiming a camera seized during World War II from Shizuo Kakutani, Member in the School of Mathematics from 1940–42

Individuals with connections to enemy countries were in some cases passing through as tourists, students, or seasonal workers, but in most cases, they had been residents of the country for many years. Some of them were born in the country, some had married a national, others had acquired nationality papers, others were in the process of getting them. Many owned houses, land, or firms and spoke the local language. The outbreak of the war transformed them—independently of their personal story, feelings, ideas, and sense of belonging—into enemy aliens, accused of posing a threat to national security and the survival of each country.

During World War I, government leaders (and sometimes armies) assumed full legislative powers and issued orders in council or decrees that limited personal freedom; restricted civil and political liberties; and eventually curbed the economic activities of the civilians of enemy nationality and jeopardized their property rights. Enemy civilians were required to register; abandon their homes in order to live in designated areas; not own cars, bicycles, and other means of transport or communication, like carrier pigeons or telegraphs; and submit to curfews. Each country adopted a combination of expulsion, repatriation, displacement, and, above all, internment of enemy nationals. Concentration camps opened almost everywhere, in Europe, in the United States, in Brazil, in the Dominions of the British Empire, and in the colonies.

Enemy aliens were prohibited from taking part in assemblies and demonstrations, owning newspapers and magazines or writing for them, and meeting in ethnic clubs and societies. In many countries ethnic presses were closed down, and the teaching of enemy foreign languages in schools was suspended. Many, trying to elude the severity of the restrictions, changed their surnames and hid their origins. Even music composed by musicians originating from enemy countries could not be played, and concert halls and opera houses had to switch to a different repertoire.

Almost all the countries at war issued a "trading with the enemy act," which prevented enemy aliens from continuing their business activities. These acts ordered the seizure, confiscation, and sometimes the liquidation of patrimonies, shops, firms, shares and assets, patents, and copyright.

Passports and nationality papers proved to be less powerful than origins in defining national identity. Denaturalization (and consequently disenfranchisement) emerged as a common practice in France, Britain, Germany, and Canada, while a ban on new naturalizations was established almost everywhere.

As the war went on, the campaign against enemy aliens extended well beyond individuals who had originated from an enemy country. The loyalty of groups of citizens was questioned based on ethnic origin, religious belief, or former nationality. Among those affected were people who had recently acquired nationality papers (for example, the Ruthenians of the Habsburg Empire who had migrated to Canada or Germans in France who very recently had acquired citizenship); women who had lost their original citizenship and acquired a new one by the way of a marriage; minorities who had national aspirations (the Armenians or the Greeks in the Ottoman Empire, the Poles, Czechs, Italians, etc., in the Austro-Hungarian Empire); minorities who were resilient to forced nationalization and had long been discriminated against (the Jews almost everywhere; the Muslims in the Russian Empire); and minorities living in border regions whose loyalty was considered difficult to ascertain (the Alsatians and Lorrainians in France, the Italians of Trentino, South Tyrol, and Istria, etc.).

Popular reaction to the government policies took many forms: complaints, informing, reporting, acts of vandalism against properties occupied by enemy aliens (shop-window smashing, the pillaging and burning of shops and houses belonging to alleged enemy aliens), verbal violence, the hunting and lynching of supposed spies and enemies on the streets or fits of public and collective hysteria. The press fueled the anti-alien feelings with articles, cartoons, pamphlets, and campaigns of racial hatred. Pacifist and liberal groups almost everywhere had difficulties voicing their opposition to such behavior.

During the Great War, juridical measures, internment, violence, and anti-alien behavior contributed to the destruction or dispersal of many ethnic groups, altering the ethnic, social, and linguistic composition of many cities and regions in Europe and elsewhere. The campaign against enemy aliens also promoted a nationalization of economies, both by expelling foreign capital and presence and by increasing state control, thus laying the framework for developments in the decades that followed. The obsession for security justified violence and violations of international law, while resorting to the use of collective category prevented for many decades the emergence of a language and practice of human rights. ■

Daniela L. Caglioti, the Elizabeth and J. Richardson Dilworth Fellow in the School of Historical Studies (2011), is a modern sociopolitical historian and Associate Professor at Università degli Studi di Napoli Federico II.

New AMIAS Board Members Reflect on Institute's Influence

The Association of Members of the Institute for Advanced Study (AMIAS), founded in 1974, supports the work of the Institute and promotes interaction between the Institute and the academic community at large. At the November 2010 annual meeting of AMIAS, five new Trustees were elected to the sixteen-person Board that governs AMIAS, which comprises some six thousand current and former Members, Visitors, and Research Assistants.

Most scholars and scientists come to the Institute with a focused initiative, but often their experiences are expansive, sometimes even transformative. Below, the five newly elected Board members recall their time at the Institute and reflect on its influence.

For me, being a Member of the School of Historical Studies in 2002–03 was the best sort of retreat. I had been working on my second book, *Romulus' Asylum: Roman Identities from the Age of Alexander to the Age of Hadrian*, for five or six years when I came to the Institute, writing bits of drafts in between everything else one does in a demanding academic position. I finished my book at IAS, and spent many hours reading and writing in an armchair in the lower floor of the library, looking out onto the small lake. I remember it as mostly frozen and snow-covered: it was a hard winter. I loved being amongst people who were completely dedicated to whatever it was they were working on, but who didn't take themselves too seriously: I think that this modesty is one of the features of the IAS community that I most prize. I also really appreciated that one could choose to share one's ideas, or indeed not share them (sometimes, one just needs to go into a zone to start having ideas), in many different formats: over lunch, in more or less formal workshops (such as our wonderful "Empires" workshop), or at one of the weekly colloquia. I loved my position at Birkbeck College, University of London, but it was very hard to go back to reality, and ultimately the IAS year left me eager for new challenges and new experiences: in January 2007, I moved to Harvard. I'm so grateful for all the opportunities that my year at IAS gave me, and not least for the wonderful friends I made in that time.

—Emma Dench, Professor of the Classics and of History, Harvard University; Member, School of Historical Studies, 2002–03

The time I spent at the School of Social Science was an invaluable intellectual and professional experience. As a junior scholar, my immersion in the rich, interdisciplinary environment at IAS definitively shaped the subsequent course of my academic career. First, I had the time and resources necessary to finish writing my second book, a project that benefited from the immense generosity, critical guidance, and practical feedback of other Members. Many of these colleagues were not only insightful interlocutors but also became dear friends, with whom I still maintain contact to this day. Second, as a single mother, having access to the exceptional childcare at Crossroads was absolutely vital in giving me the peace of mind necessary to concentrate on my research and produce the quality of scholarship necessary to achieve tenure. Most importantly, I had the opportunity to work together with Professor Joan Scott. The chance to share arguments and ideas with her was like drinking a bucket of cerebral Miracle-Gro. Professor Scott's selflessness as a mentor encouraged me to push myself beyond my theoretical comfort zones and to challenge prevailing paradigms, skills that continue to enrich all of my scholarly work and for which I am deeply grateful.

—Kristen Ghodsee, John S. Osterweis Associate Professor of Gender and Women's Studies, Bowdoin College; Member, School of Social Science, 2006–07

I remember fondly the two years I spent at IAS working with Steve Adler on the experimental implications of unified field theories of elementary particle interactions. We also tackled a very hard problem that still is unsolved—how to reconcile general relativity with quantum field theory. I especially enjoyed the Institute's rich, intellectually stimulating environment and many intense discussions with Members across disciplines at lunch or at tea or evening dinners. I have spent my life in elite institutions and it's fair to say that none has come close to providing the intellectually engaging atmosphere that I cherished at the Institute. Although my work at the Institute was productive (seven research papers came out of it), while there I decided to abandon physics to do work that was more down-to-earth, which could more directly contribute to human well-being.

During a walk in the Institute Woods with a friend, I decided that I didn't want to spend the rest of my life alone in an office grappling with a few equations. My decision to go to medical school to become a physician scientist led to a very different life, but it's also been very gratifying.

—Judy Lieberman, Senior Investigator, Immune Disease Institute and Program in Cellular and Molecular Medicine, Children's Hospital Boston; Professor of Pediatrics, Harvard Medical School; Member, School of Natural Sciences, 1974–76

I was at the Institute for the academic year 1971–72 as Research Assistant to Clifford Geertz. This was prior to the establishment of the School of Social Science in 1973, so the number of social scientists was only a handful, including myself, the only junior member. I learned a great deal during that year, particularly from Clifford Geertz and David Riesman, both of whom were exceptionally generous and inspiring mentors. Equally important was my interaction with other Members, and in particular a group of young physicists with whom I engaged in a wide-ranging cross-disciplinary dialogue over lunch on most days. In my experience, the Institute truly lived up to its reputation as a haven for complete intellectual liberty. Shortly after my stay at the Institute, I left the academic world to pursue a career in finance, which resulted in overseas assignments for some thirty years. In the business world, the words "academic" and "intellectual" have negative connotations, and I was often advised by search consultants not to include my year at the Institute on my CV, but I always insisted on keeping it there. In my mind, the year I spent at the Institute was a major factor in my success in the business world. Upon retirement in 2006, I returned to live in Princeton, partly because of the attraction of the Institute.

—Fouad J. Masrieh, Research Assistant, School of Social Science, 1971–72

I have spent three periods of time in residency at IAS, and I am looking forward to a fourth in the spring of 2012. In 1979–80, one of the first special years in mathematics at IAS took place, organized by S. T. Yau, who shortly afterwards received a Fields Medal and became a permanent member of the mathematics Faculty. The year was full of activities: we had an eating group, played volleyball, and took part in at least three active ongoing seminars. I had spent two years (during the Vietnam War) at U. C. Berkeley, but since then had not been in the midst of the relatively new field of applying partial differential equations to geometry. The year at IAS allowed me to take part in this development and to form the collaborations that were essential to the next decade of my career. This has been an exciting area of mathematics; the privilege I have had of working in it is partly due to this year at IAS. I returned in 1995 for the fall term, which was a good experience, but too short. I particularly enjoyed meeting Members from other Schools at lunch and tea, and I found it a great place to work, especially to write up material I had worked on for several years. I was then invited to organize a special year in 1997–98, in which I tried to connect researchers working on the algebraic aspects of partial differential equations with those working on more analytic estimates. This is the shadow of difficulty that also exists in theoretical physics. This is a long-term project of mine, which I don't think has led where I would like to see it go. I hope that I was able to encourage the younger Members, as I had been encouraged eighteen years before. If I have any regrets, it is that I did not spend enough time in contact with Members of other disciplines. I hope to remedy this in the spring of 2012.

—Karen K. Uhlenbeck, Professor of Mathematics and Sid W. Richardson Regents Chair, University of Texas, Austin; Member, School of Mathematics, 1979–80, 1995, 1997–98

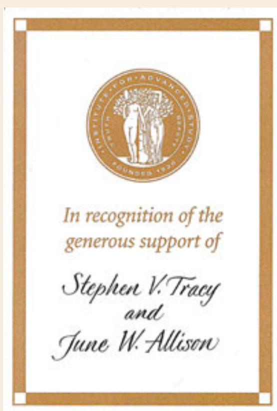
CORY WEAVER

Peter Galison

AMIAS LECTURE – NOVEMBER 11, 2011

Objectivity: The Limits of Scientific Sight

As part of the annual meeting of the Association of Members of the Institute for Advanced Study to be held on November 11, Peter Galison, Joseph Pellegrino University Professor at Harvard University and a former Institute Trustee, will give a public lecture, "Objectivity: The Limits of Scientific Sight." Galison will discuss the evolution and limits of objectivity and how reproduction of images has begun to cede to something more directly productive of new objects—presentation instead of representation. The lecture will take place at 5:00 p.m. in Wolfensohn Hall. For more information, contact amias@ias.edu or Linda Cooper at (609) 734-8259.



While the Institute welcomes gifts of any amount, some former IAS scholars find that they are able to make gifts of a larger size. Such contributions have a significant impact on the Institute's ability to fund its programs and, in particular, the work of current Members. To recognize this exceptional support from its former Members and Visitors, the Institute has created three leadership giving categories, the Flexner, Aydelotte, and Oppenheimer Circles, with benefits offered at each level. All Circles' donors are recognized for their generosity with a specially designed bookplate in an IAS library book whose purchase has been facilitated in part by the donation. Stephen V. Tracy and June W. Allison are among the founding members of the Oppenheimer Circle. For more information about the Circles opportunities, visit www.ias.edu/people/amias.

Institute Libraries: A Legacy of Donations

The first Institute Faculty recognized that a strong, working library was critical to the work of the Institute. Books were purchased as early as 1934, five years before the opening of Fuld Hall. The volumes were designated with an Institute bookplate and placed in the Princeton University Library for the Humanities and Fine Hall Mathematics Library to be used by both communities.

Faculty members acted as purchasing agents for book and journal acquisitions. Benjamin Meritt, the first Professor in the School of Humanistic Studies (a precursor with the School of Economics and Politics of the current School of Historical Studies) set up a working epigraphical library, built the Institute's collection of squeeze inscriptions in the 1930s (see the *Institute Letter*, Fall 2010), and arranged for books to be sent from Greece to 20 Nassau Street, the primary office of the Institute at the time.

In January 1940, Frank Aydelotte, the Director of the Institute, reported to the Board of Trustees that without a library, scholars would be unable to work in Fuld Hall and would have to spend more time in Princeton University's Fine Hall. Aydelotte estimated that the School of Mathematics would need about $40,000 and that the other two Schools—Humanistic Studies and Economics and Politics—would need another $60,000, equivalent to about $1.5 million today. The "library problem" was solved in 1940, thanks to a gift of $25,000 per year for four years from the Institute's founders, Louis Bamberger and his sister Caroline Bamberger Fuld. The Institute Library adopted the hours set by Fine Hall's Mathematical Library, which remained open twenty-four hours a day.

The original Institute Library was located on the second floor of Fuld Hall, and it grew steadily, due in part to donations from Faculty and Members. Among these early generous individuals was Hetty Goldman, the first female Professor in the School of Humanistic Studies, who donated her library in 1950. Edward Capps, an early Member also affiliated with the School, funded the Loeb Classical Library at the Institute and served as the first American editor of the series. Ernst H. Kantorowicz, a medievalist and a member of the School of Historical Studies Faculty, donated his library and a small collection of Greek vases. Two founding Professors of the School of Mathematics, Hermann Weyl, who also served as the first librarian of the Institute, and Oswald Veblen gave books to the Institute in 1956 and 1960, respectively. "I am delighted that the library is developing into so active and important a part of the Institute," Aydelotte wrote to Library Assistant Dorothy Halmos in September 1940.

Other notable donations that augmented the Library's collections include a collection of first editions in the history of science and bibliography presented in the 1950s by Lessing J. Rosenwald, Chairman of Sears, Roebuck and Co. and a Trustee of the Institute from 1940 to 1979. The memorial book fund established in memory of Leon Levy, a Trustee from 1988 to 2003, continues to make possible the acquisition of special collections, particularly in the history of ideas. The Usdan Fund established by Leo Usdan, who was not affiliated with the Institute, supports mathematics and sciences. In 1964, the humanities collection moved from Fuld Hall to the newly constructed Historical Studies–Social Science Library designed by Wallace K. Harrison and built during J. Robert Oppenheimer's tenure as Director. The Mathematics–Natural Sciences Library and the Historical Studies–Social Science Library continue to develop specialized and selective collections under the guidance of Faculty and Members, providing an important research resource for the Institute community. For more information on the collections, staff contacts, or to view the desiderata list, please visit the libraries website, http://library.ias.edu/. ■

Record Gifts from Friends of the Institute

In 2010–11, gifts provided by the Friends of the Institute for Advanced Study reached an all-time high, with $771,000 raised against a $750,000 goal. Members of the Friends Executive Committee gathered with Director Peter Goddard (center) at the annual meeting of the Friends in May. Friends play a vital role in Institute life, linking it to the broader community, acting as informed ambassadors for the work conducted at the Institute, and helping to maintain the Institute's financial independence through their generous annual contributions. For more information about the Friends, please visit www.ias.edu/people/friends or contact Pamela Hughes at (609) 734-8204 or phughes@ias.edu.

ANDREA KANE

Contributions to IAS History from Louise Morse

COURTESY OF LOUISE MORSE

BY LINDA G. ARNTZENIUS

The above photograph (ca. 1958) of Marston Morse (1892–1977), Professor in the School of Mathematics, and his wife Louise is a rare image from one of two albums compiled by Louise Morse over seven decades. It is unusual in that it includes Louise herself. Louise was often the one behind rather than in front of the camera. Her two packed volumes reveal the Institute's mathematical community at leisure. Enhanced with newspaper clippings and carefully annotated with names and dates, the albums, which have been promised to the Shelby White and Leon Levy Archives Center, are a treasure trove of snapshots taken at the annual gatherings of Institute Faculty, Members, Visitors, and their families held by Marston and Louise in their home.

Marston and Louise Morse were known as generous and engaging hosts, inviting groups of twenty mathematicians at a time on four separate occasions throughout the year. Louise made a point of knowing the name of every guest so that she could introduce newcomers. After her husband's death, she continued the tradition with annual parties that coincided with the annual Marston Morse Lectures each spring.

The couple met mid-Atlantic in 1936 when Marston spotted Louise and her three friends dancing onboard ship. He had joined the Faculty of the Institute for Advanced Study the year before, taking his place alongside James W. Alexander, Albert Einstein, Oswald Veblen, John von Neumann, and Hermann Weyl. Born in Waterville, Maine, Morse was a talented pianist who had to choose between a career in music or mathematics. He is recognized for defining a new branch of mathematics (differential topology) known as Morse theory. In 1936, he was on his way to Europe to lecture in mathematics. Louise, who grew up in Hanging Rock, Ohio, had just graduated in nursing from Johns Hopkins and was taking a six-week trip with her friends. Although Morse was a good deal her senior, she accepted his invitation to dance. They were married in 1940 (she was twenty-eight, he was forty-seven), and took up residence at 40 Battle Road—which became a second home to those mathematicians from around the world visiting the Institute.

A cherished member of the Institute community, Louise celebrated her one hundredth birthday in June. Her memories reach back to teas with Elizabeth Veblen, cocktails with the von Neumanns, and dinners with the Oppenheimers at Olden Farm. Shortly after her marriage, she found herself seated next to Albert Einstein at a dinner hosted by Abraham Flexner and his wife Anne Crawford Flexner in New York City. Although Einstein joked that he didn't know what to say to a new young bride, it was Louise who recalls being at a loss for words. Later she and Einstein would share a common cause in deploring the unequal treatment of African Americans in America and in Princeton. Louise is well-known as a loyal supporter of the Princeton Committee of the NAACP Legal Defense and Educational Fund, which paid tribute to her contributions and commitment last October.

In May, Louise donated a first edition of Abraham Flexner's autobiography *I Remember* to the Shelby White and Leon Levy Archives Center. Louise pasted various personal mementos into the book, including personal correspondence between the Flexners and the Morses between 1940 and 1956. The book is inscribed by the author in honor of the birth of Louise and Marston's daughter Julia. ■

COURTESY OF LOUISE MORSE

Louise's two packed volumes reveal the Institute's mathematical community at leisure.

Linda G. Arntzenius, a member of the Institute's Public Affairs staff from 2003–06, is the author of Images of America: Institute for Advanced Study *(Arcadia Publishing), which is dedicated to Louise Morse and includes a selection of images from Louise's albums.*