IAS

The Institute Letter

Institute for Advanced Study

Spring 2011

DNA, History, and Archaeology

BY NICOLA DI COSMO

Historians today can hardly answer the question: when does history begin? Traditional boundaries between history, protohistory, and prehistory have been blurred if not completely erased by the rise of concepts such as "Big History" and "macrohistory." If even the Big Bang is history, connected to human evolution and social development through a chain of geological, biological, and ecological events, then the realm of history, while remaining firmly anthropocentric, becomes all-embracing.

An expanding historical horizon that, from antiquity to recent times, attempts to include places far beyond the sights of literate civilizations and traditional caesuras between a history illuminated by written sources and a prehistory of stone, copper, and pots has forced history and prehistory to coexist in a rather inelegant embrace. Such a blurring of the boundaries between those human pasts that left us more or less vivid and abundant written records, and other pasts, which, on the contrary, are knowable only through the spadework and fieldwork of enterprising archaeologists, ethnographers, and anthropologists, has also changed (or is at least threatening to change) the nature of the work of professional historians.

(Continued on page 12)

"Spontaneous Revolution" in Tunisia

Yearnings for Freedom, Justice, and Dignity

BY MOHAMED NACHI

REUTERS/ZOHRA BENSEMRA

Protests in Tunisia culminated when Zine el-Abidine Ben Ali, who had ruled for twenty-three years, fled on January 14, 2011.

The Tunisian revolution of 2011 (*al-thawra al-tunisiya*) was the result of a series of protests and insurrectional demonstrations, which started in December 2010 and reached culmination on January 14, 2011, with the flight of Zine el-Abidine Ben Ali, the dictator who had held power for twenty-three years. It did not occur in a manner comparable to other revolutions. The army, for instance, did not intervene, nor were there actions of an organized rebellious faction. The demonstrations were peaceful, although the police used live ammunition, bringing the death toll to more than one hundred.

The demonstrations began in the town of Sidi Bouzid, west of the country's geographical center. On December 17, 2010, a young street vendor set himself on fire following the confiscation of his wares (fruits and vegetables) by the police. Mohamed Bouazizi was twenty-six, and he succumbed to his burns on January 4. The next day, five thousand people attended his funeral. He became the symbol of the liberation of the Tunisian people from the despotic rule of the Ben Ali regime. The population, and predominantly the youth, began to demonstrate with calm determination, in order to

(Continued on page 8)

Knots and Quantum Theory

BY EDWARD WITTEN

In everyday life, a string—such as a shoelace—is usually used to secure something or hold it in place. When we tie a knot, the purpose is to help the string do its job. All too often, we run into a complicated and tangled mess of string, but ordinarily this happens by mistake.

The term "knot" as it is used by mathematicians is abstracted from this experience just a little bit. A knot in the mathematical sense is a possibly tangled loop, freely floating in ordinary space. Thus, mathematicians study the tangle itself. A typical knot in the mathematical sense is shown in Figure 1. Hopefully, this picture reminds us of something we know from everyday life. It can be quite hard to make sense of a tangled piece of string—to decide whether it can be untangled and if so how. It is equally hard to decide if two tangles are equivalent.

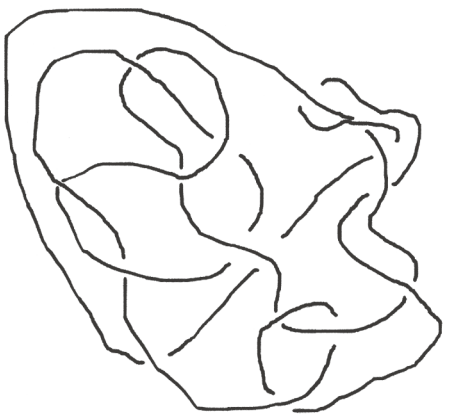


Figure 1

Such questions might not sound like mathematics, if one is accustomed to thinking that mathematics is about adding, subtracting, multiplying, and dividing. But actually, in the twentieth century, mathematicians developed a rather deep theory of knots, with surprising ways to answer questions like whether a given tangle can be untangled.

But why—apart from the fact that the topic is fun—am I writing about this as a physicist? Even though knots are things that can exist in ordinary three-dimensional space, as a physicist I am only interested in them because of something surprising that was discovered in the last three decades. Much of the theory of knots is best understood in the framework of twentieth- and twenty-first-century developments in quantum physics. In other words, what really fascinates me are not the knots per se but the connections between the knots and quantum physics.

The first "knot polynomial" was actually discovered in 1923 by James W. Alexander. Alexander, a Princeton native who later was one of the original Professors at the Institute, was a pioneer of algebraic topology. But the story as I will tell it begins with the Jones polynomial, which was discovered by Vaughan F. R. Jones in 1983. The Jones polynomial was an essentially new way of studying knots. Its discovery led to a flood of new surprises that is continuing to this very day.

Even though it is very modern, and near the frontier of contemporary mathematics, the Jones polynomial can be described in such a down-to-earth way that one could explain it to a high school class without compromising very much. There are not many frontier developments in modern mathematics about which

(Continued on page 4)

News of the Institute Community

DANIELLE S. ALLEN, UPS Foundation Professor in the School of Social Science, has published *Why Plato Wrote* (Wiley-Blackwell, 2010), which argues that Plato was an activist who wrote to change Athenian society and thereby transform Athenian politics. Allen has also been named to the Commission on the Humanities and Social Sciences, recently established by the American Academy of Arts and Sciences to bolster teaching and research in the humanities and social sciences.

DIDIER FASSIN, James D. Wolfensohn Professor in the School of Social Science, has been appointed to the International Commission of Scientific and Strategic Orientation of the Collège de France, recently created to analyze and make recommendations regarding conditions for fulfilling the institution's missions.

CHRISTIAN HABICHT, Professor Emeritus in the School of Historical Studies, has had his Sather Lectures of 1982 published in Greek. *O Perihghths Pausanias* (Institute of the Book A. Kardamitsa, 2010) was first published in 1985 as *Pausanias' Guide to Ancient Greece* (University of California Press) and as *Pausanias und seine "Beschreibung Griechenlands"* (C.H. Beck).

PETER PARET, Professor Emeritus in the School of Historical Studies, has been awarded the American Historical Association's inaugural Jack Miller Center Prize for his essay on Marc Bloch and Carl von Clausewitz, "Two Historians on Defeat in War and Its Causes," which appeared in *Historically Speaking* XI:3 (June 2010).

JOHN W. MILNOR, former Professor (1970–90) in the School of Mathematics, received the 2011 Abel Prize from the Norwegian Academy of Science and Letters for his pioneering discoveries in topology, geometry, and algebra. He also was awarded the Leroy P. Steele Prize for Lifetime Achievement by the American Mathematical Society. Milnor is currently Co-Director of the Institute for Mathematical Sciences at Stony Brook University.

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.

MARTIN REES, Trustee of the Institute and former Member (1969–70, 1973, 1975, 1982, 1992–93, 1996) in the School of Natural Sciences, has been awarded the 2011 Templeton Prize. Rees is currently Master of Trinity College in the University of Cambridge, where he is also Professor Emeritus of Cosmology and Astrophysics.

PAUL MORAVEC, former Artist-in-Residence (2007–08) and Artistic Consultant (2008–09), will premiere *Danse Russe* at the Philadelphia International Festival of the Arts in April. Moravec is University Professor at Adelphi University.

The American Mathematical Society has honored CHANDRASHEKHAR KHARE, Member in the School of Mathematics, along with Jean-Pierre Wintenberger, with the Frank Nelson Cole Prize in Number Theory for their proof of Serre's modularity conjecture. Khare has also received the Infosys Prize, presented to recognize outstanding scientific research contributing to the development of India. Khare is Professor of Mathematics at the University of California, Los Angeles.

NORMAN BIRNBAUM, former Member (1975–76) in the School of Social Science, has been awarded the Cruz Onor de la Orden de San Raimundo de Peñafort by the Spanish Ministry of Justice. Birnbaum is Professor Emeritus at Georgetown University Law Center.

BENJAMIN C. BROWER, former Member (2007–08) in the School of Social Science, has been awarded the Middle East Studies Association's Albert Hourani Book Award for *A Desert Named Peace: The Violence of France's Empire in the Algerian Sahara, 1844–1902* (Columbia University Press, 2009). Brower, Assistant Professor in the Department of History at the University of Texas at Austin, worked on the book while in residence at the Institute.

INGRID DAUBECHIES, former Member (1999) in the School of Mathematics, received the Leroy P. Steele Prize for Seminal Contribution to Research from the American Mathematical Society. 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.

RHONDA HUGHES, former Member (1982–83) in the School of Mathematics, received the M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics from the Association of Women in Mathematics. Hughes is the Helen Herrmann Professor of Mathematics at Bryn Mawr College.

HENRYK IWANIEC, former Member (1983–84, 1986–88, 1999–2000) in the School of Mathematics, received the Leroy P. Steele Prize for Mathematical Exposition from the American Mathematical Society. Iwaniec is New Jersey Professor of Mathematics at Rutgers, the State University of New Jersey.

Two former Members in the School of Mathematics, PETER KRONHEIMER (1987–88, 1988–89) and TOMASZ MROWKA (2003–04), shared the Joseph L. Doob Prize of the American Mathematical Society for their book *Monopoles and Three-Manifolds* (Cambridge University Press, 2007). Kronheimer is William Casper Graustein Professor of Mathematics at Harvard University and Mrowka is Singer Professor of Mathematics at the Massachusetts Institute of Technology.

ADEREMI KUKU, former Member (2003–04) in the School of Mathematics, has been presented with the Nigerian National Order of Merit. KuKu is William W. S. Claytor Endowed Professor of Mathematics at Grambling State University.

RACHEL MANDELBAUM, former Member (2006–09) in the School of Natural Sciences, has received the Annie J. Canon Award in Astronomy from the American Astronomical Society, presented for outstanding research by a postdoctoral female researcher. Mandelbaum is an Associate Research Scholar in the Department of Astrophysical Sciences at Princeton University.

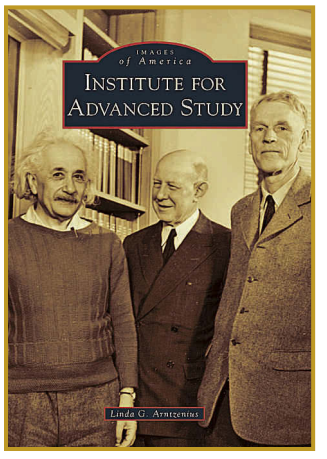
HERBERT SPOHN, former Member (1990) in the School of Mathematics, has been awarded the 2011 Dannie Heineman Prize for Mathematical Physics by the American Institute of Physics and the American Physical Society for his seminal contributions to nonequilibrium statistical mechanics. Spohn also received the Leonard Eisenbud Prize for Mathematics and Physics from the American Mathematical Society. Spohn is Professor at the University of Technology, Munich.

DAVID VOGAN, former Member (1977–78, 1978–79) in the School of Mathematics, received the Levi L. Conant Prize from the American Mathematical Society. Vogan is Professor of Mathematics at the Massachusetts Institute of Technology.

PETER WINKLER, former Member (2003–04) in the School of Mathematics, shared the Mathematical Association of America's David P. Robbins Prize with Mike Paterson, Yuval Peres, Mikkel Thorup, and Uri Zwick. Winkler is Professor of Mathematics at Dartmouth College.

PETER GODDARD, Director of the Institute for Advanced Study since January 2004, has announced that he will step down as Director on June 30, 2012. After that date, he will remain at the Institute as a Professor working in the School of Natural Sciences.

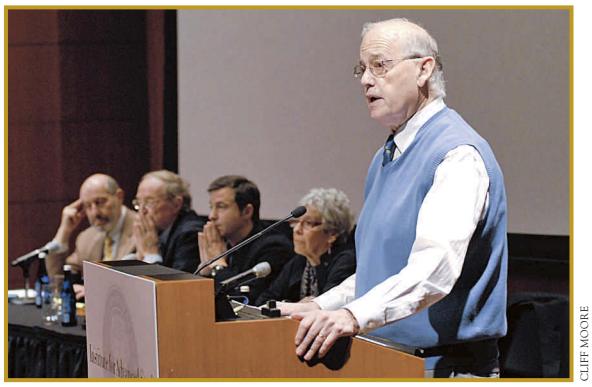
Images of America: Institute for Advanced Study Now Available



Images of America: Institute for Advanced Study, a pictorial history by Linda G. Arntzenius, has been published by Arcadia Publishing. The book features some 189 images, drawing upon the Institute's archives along with images from the collections of Princeton residents and others. The book is available now in bookstores and online. A video of the author speaking about the book to the Einstein Legacy Society, which recognizes individuals who have made a planned gift or included the Institute in their estate plans, is available at www.ias.edu/support/planned-gifts/#arntzenius. ■

Examining the Human Experience

ANDREA KANE



CLIFF MOORE

Events celebrating the Institute's eightieth anniversary included a discussion on gender's role in the fields of history and social science by Joan Wallach Scott (left) and Caroline Walker Bynum (middle), and a panel on human rights moderated by Harold Shapiro, an Institute Trustee.

The rights, tensions, and ideas that inform the contemporary human experience were explored by the Schools of Historical Studies and Social Science last fall during a weekend of programs in honor of the Institute's eightieth anniversary. The discourse, excerpts of which appear below, examined the power of anonymous speech in antiquity and on the Internet; the sublimation of emotion in amnesty and political theatricality; the influence of gender on the reinterpretation of the fields of history and social science; and the conception and challenges of human rights from historical, philosophical, political, and sociological perspectives.

"Anonymous speech shifts costs from the speaker to the listener. The listener has to figure out who is speaking, what their motives are, what the reason is for their anonymity, and in doing so, in making all those interpretations, a listener can go badly wrong. . . . Anonymity also blurs the formal but artificial line between private and public, and uses intimacy to establish trust that can have political consequences."
—Danielle S. Allen, UPS Foundation Professor, School of Social Science

"As far as we can know, the Greeks were the first who established the institution of amnesty. . . . The Greeks responded to the fundamental dilemma of amnesty, which is the choice between the right of the dead—the right of revenge—and the advantage of the living—reconciliation and concord. This is a conflict between emotion—anger—and reason—reconciliation and going ahead with life in a peaceful society."
—Angelos Chaniotis, Professor, School of Historical Studies

"The exclusive valorization of the right to life has problematic implications. First, it often obliterates competing rights, and particularly social and economic rights. Second, it generally disqualifies the claims of others, when they defend different values as their priority."
—Didier Fassin, James D. Wolfensohn Professor, School of Social Science

"The dark side of human rights—dark in the sense of the unobserved—is that people have thought a great deal about the entitlements and the rights of people, and they haven't thought hard enough about the obligations. Whose duty is it to protect human rights? This remains so vague that human rights in many cases become manifesto rights and not real rights. A right is not a right without remedy; it is just a rhetorical device."
—Avishai Margalit, George F. Kennan Professor, School of Historical Studies

"I don't think that terms like 'privacy' or 'secularism' or even 'rights' have absolute meaning. I think that many of the questions about what these things mean can only be answered historically, and then the historical answer actually looks at the political contests and arguments that have been made about these terms, and those which have prevailed, and those which haven't. It seems to me that's how we get to understand what political work these philosophical concepts can do, have done, and what spaces there are to use them for the kinds of claims that we want to make."
—Joan Wallach Scott, Harold F. Linder Professor, School of Social Science ■

New Giving Program Supports Memberships

Contributions to the Institute by former Members and Visitors currently provide support for two Members each year. The Institute would like to encourage giving in this area so that these contributions can support a Member from each of the four Schools annually. There are now several new opportunities for Members to help the Institute achieve this goal.

Neil Chriss, former Member (1994–95) in the School of Mathematics, has set a $50,000 matching challenge—he will match dollar for dollar any new gift to the Institute by a former Member or Visitor. He also will match increases in giving over last year, and any contribution made after a lapse of a year or more. Donors may designate both their gift and the matching gift to the School or purpose of their choice. The response from former Members and Visitors has been overwhelmingly positive: in the fiscal year to date, more than three hundred donors have contributed more than $90,000 to the Institute, with 156 gifts qualifying for Chriss's match, totaling more than $39,000.

In addition, while the Institute welcomes gifts of any amount, past Members and Visitors may now participate in a new leadership giving program. The Flexner, Aydelotte, and Oppenheimer Circles, named for the Institute's first three Directors, offer benefits associated with each level of support.

"As a former Member who is permanently grateful for the ways that the Institute supported my own research and publication, the new leadership giving program challenged us to give more and encourages an active engagement with the Institute community," said Paul Rorem, a former Member (1998–99, 2006–07) in the School of Historical Studies. "That our gift will be matched is a delightful bonus."

Donors to the Flexner Circle ($500–$999) will receive priority ticketing for the Institute's Edward T. Cone Concert Series and will be listed in the Institute's annual report as leadership donors and Circles members.

Donors to the Aydelotte Circle ($1,000–$1,499) and Oppenheimer Circle ($1,500 and more) will receive all of the benefits described above, as well as an Institute ID card, providing access to the Institute's Dining Hall for lunches and dinners.

Additionally, members of the Oppenheimer Circle will receive invitations to Friends of the Institute events (see article, page 13) and may use the Institute's guesthouse, Marquand House, for overnight accommodations.

To learn more about these new opportunities to support the Institute, please contact Linda Geraci, Development Officer, at llg@ias.edu or (609) 734-8259. ■

Community of Scholars Database Available Online

A comprehensive database of the scholars associated with the Institute for Advanced Study since its founding, the online Community of Scholars (CoS) database, is now available at www.ias.edu/people/cos. To access a detailed profile for each individual listed, members of the community may use their current IAS or CoS credentials to log in by clicking the "Member Login" tab in the upper right corner. Once logged in, each scholar's name will be hyperlinked to a more detailed profile. If you no longer recall the login credentials that were provided, please click on the "forgot my password" link on the login page.

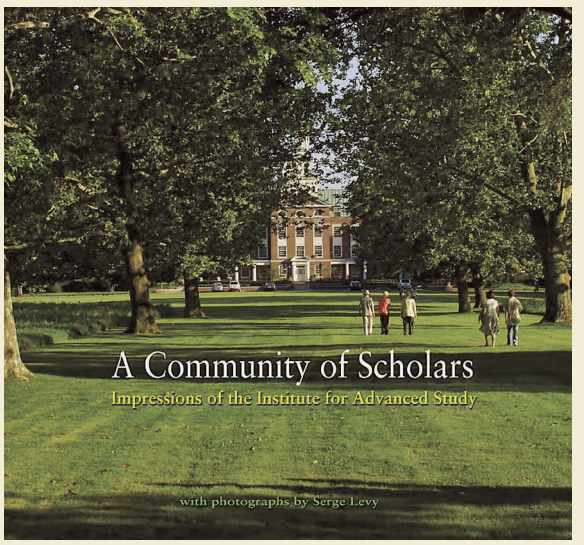
This project extends work that began in 1955, to mark the twenty-fifth anniversary of the founding of the Institute, when a volume was compiled with a bibliographical entry for everyone who had been affiliated with the Institute up to that time. The data was brought up to date in 1980 on the occasion of the Institute's fiftieth anniversary and published as *A Community of Scholars: The Institute for Advanced Study 1930–1980*.

Those who were invited to submit additional biographical and bibliographical information for their profiles last year are encouraged to review their records and update them moving forward. The profiles include information submitted by scholars or drawn from the 1980 book and other Institute sources. In addition to updating the 1980 book, as it develops, the CoS database aims to provide a resource for former and current scholars, helping them maintain their contact with the Institute and with each other.

This project is an ongoing initiative, and it is hoped that the data will continue to be refined by individuals themselves and through updates made by IAS staff. For assistance or to submit any feedback or comments, please contact cos@ias.edu. ■

PRE-ORDER NOTICE

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 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 Serge Levy during the 2009–10 academic year and personal reflections by Sir 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. ■

one could make such a claim. For example, no one would try to explain Andrew Wiles's proof of Fermat's Last Theorem to high school students.

To simplify slightly (see the box on page 5 for more details), what Jones discovered was a way to calculate a number for every knot. Let us call our knot K, and we will write J_K for the number that Jones calculates for this knot. There is a definite rule that allows you to calculate J_K for any knot. No matter how complicated K may be, one can calculate J_K if one is patient enough.

If J_K is not equal to 1, then the knot K can never be untangled. For example, let us go back to the knot that was sketched in Figure 1. If you were to think about how to untie that particular knot, you certainly would not succeed. But how could one prove that it is impossible? Jones gave a way to answer this sort of question: calculate J_K, and if it is not equal to 1, then the knot K can never be untied. Jones's method of computing J_K was very clever, but once it was found, anyone could use it without any particular cleverness, just by following instructions.

In fact, there are an astonishing variety of ways to calculate J_K. I will explain just one of the simplest. One important rule applies to the "unknot," which is a

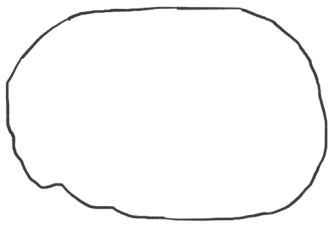


Figure 2

simple untangled loop (Figure 2). If K is an unknot then $J_K=1$.

For all other knots, we have to play a little game. To start, we pick three favorite numbers, for example 2, 3, and 10. Now we are going to do something that might seem to make life more complicated. Instead of a single knot K, we are going to consider three knots K, K', and K''. If the three knots that we pick are related in a certain way, there will be an arithmetic relationship

$$2\,J_K + 3\,J_{K'} + 10\,J_{K''} = 0$$

This relationship—or, as mathematicians call it, this identity—is so powerful that it enables us to calculate the J's.

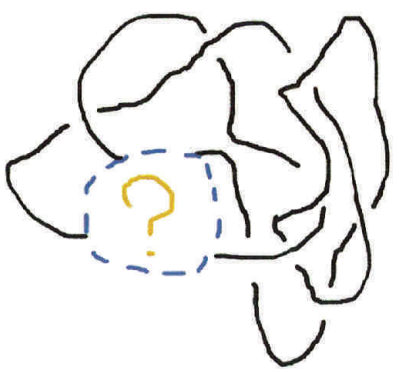


Figure 3

How should K, K', and K'' be related in order to participate in such an identity? In Figure 3, I have drawn a partial knot. It is only a partial knot because there is a missing piece, indicated by the question mark. There are many possible ways to complete the knot by filling in the missing piece. In Figure 4, I have sketched three of the simplest ways to do this. Choosing one of these three fillings gives us a knot that we call K, K', or K'', respectively, and then, as stated previously, we declare that Jones's numbers J_K, $J_{K'}$, and $J_{K''}$ obey the relationship $2\,J_K + 3\,J_{K'} + 10\,J_{K''} = 0$.

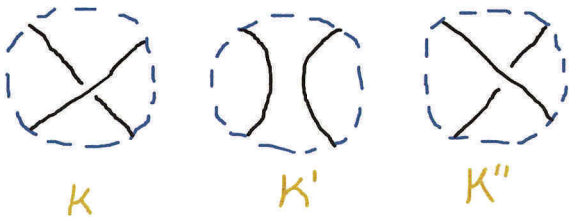


Figure 4

It turns out that this is a rather powerful relationship, which enables one to calculate J_K for any K. The details of this are explained somewhat more fully in the box (on page 5).

The surprise here is not so much that this rule can be used to calculate J_K, but that in doing this one never runs into a contradiction. One could anticipate a contradiction because actually there are many ways to use the properties that I have described to calculate J_K. However, Jones and other mathematicians showed in the 1980s that there is never a contradiction—one always arrives at the same answer for J_K no matter how one uses the procedure just described (or the other, related, procedures that were discovered in that period) to calculate it.

These proofs showed that the recipes for calculating J_K were correct, but they left a "why" question. Unfortunately, it is not that easy to explain to someone who does not work in mathematics or physics or an allied field the difference between knowing "what" is true and knowing "why" it is true. Yet the beauty of the "why" answers is much of the reason that people do mathematics.

In this case, as people worked on the Jones polynomial, they discovered more and more remarkable formulas, with less and less clarity about what they meant.

But there was a clue. In fact, there were a lot of clues. As the subject developed, beginning with Jones's original work, it had many ties with mathematical physics . . . bewilderingly many. If anything, too many links were found between the Jones polynomial and mathematical physics. Sometimes it is better to have one good clue than a dozen of doubtful merit!

Personally, I was most influenced during this period by the work of IAS Members Erik Verlinde, Greg Moore, and Nati Seiberg (Seiberg is now a Professor in the School of Natural Sciences) and of the Japanese mathematicians Akihiro Tsuchiya and Yukihiro Kanie, and by the suggestions of former IAS Professor Michael Atiyah.

It turned out that the explanation of the Jones polynomial has to do with quantum theory. So I need to explain a little of how quantum theory differs from pre-twentieth-century physics.

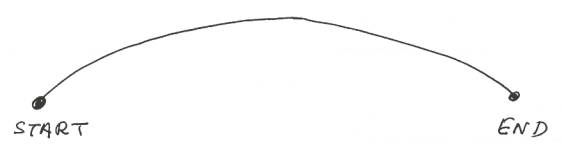


Figure 5a

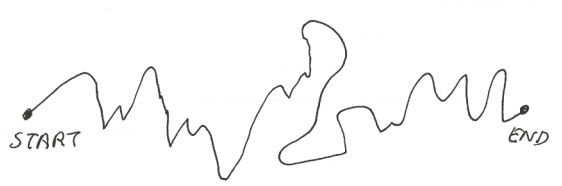


Figure 5b

A classical particle that is traveling between one point and another gets there on a nice orbit that obeys Newton's laws (Figure 5a). In contrast, a quantum particle can follow any path at all. A fairly typical path might be quite irregular (Figure 5b). For the quantum particle, we have to allow all possible paths, with any number of loops and zigzags.

An important point to emphasize is that we are relativistic physicists, since relativity was also invented in the twentieth century, along with quantum mechanics. So when I draw a path, it is really a path in spacetime, not a path in space.

The physical dimension of the real world we live in is therefore four—three space dimensions and one dimension of time. But to understand knot theory, at least for the moment, we are going to imagine a world of only three spacetime dimensions—two space dimensions and one time dimension.

In a world of three spacetime dimensions, the particle path might be knotted. For an example of a knotted path, see Figure 6.

A quantum physicist has to sum the effects of all possible paths by which a particle might reach its destination. How to calculate such a sum is what physicists

Figure 6

learned in constructing quantum theory and what is now the Standard Model of particle physics.

Quantum mechanically, though any path is possible, if the particle traveled on a particular path K, then there is a "probability amplitude" for it to arrive at its destination, and this amplitude depends on K. The way that the amplitude depends on K is very important—it is the reason that there is some order even in a quantum universe. All paths are possible, but peculiar ones with a lot of zigzags are not very likely.

The quantum mechanical amplitude that the particle traveled on a path K is given by something called the Wilson operator, W_K. For our purposes, we really do not need to know how it is defined. All we need to know is that it is a basic ingredient in quantum physics; for instance, physicists use it in calculating the force between quarks.

The connection between the Jones polynomial and quantum physics turns out to be simply that if we regard a knot K as the orbit in spacetime of a charged particle, then the Jones polynomial is the average value of the Wilson operator. Thus the quantum formula for the Jones polynomial is just $J_K = \langle W_K \rangle$, where the symbol $\langle\ \rangle$ represents a process of quantum averaging.

When one carries out this program, the version of quantum theory that is relevant uses something called the Chern-Simons function for gauge fields. (Both Shiing-Shen Chern, who founded much of modern differential geometry, and James Simons, now an Institute Trustee, are former IAS Members.)

This story as I have told it so far goes back to my early years at the Institute. But there is actually a more contemporary twist to this tale. This is the reason that it seems timely to write about this topic now.

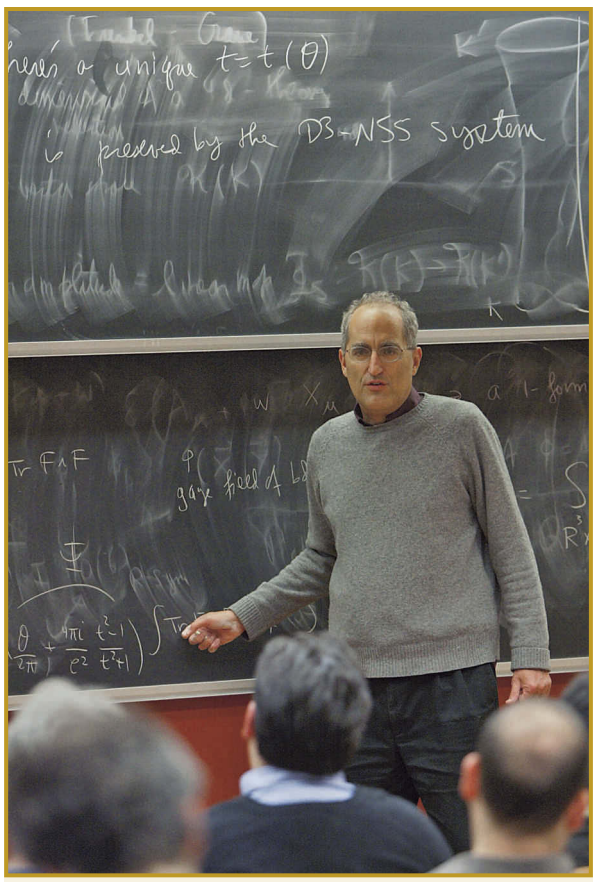
In everyday life, a knot is a physical object that exists in space, but to interpret the Jones polynomial in terms of quantum theory, we have instead had to view a knot as a path in a spacetime of only three dimensions. This is perhaps a less obvious viewpoint about what a knot means.

However, around 1990, when he was a Member at the Institute, Igor Frenkel started to develop what he hoped would be a new mathematical theory in which the knot would indeed be seen as a physical object rather than a path in spacetime. The new theory was supposed to involve a more powerful version of the Jones polynomial.

I wish I could say that I gave Frenkel some useful advice, but all I did was to tell him that it would not work because the Chern-Simons function is special to three dimensions and does not have the right sort of extension to four dimensions. It actually was a sensible objection at the time, and I am still surprised that it turned out to be wrong.

Anyway, Frenkel continued to develop this idea with, among others, his student Mikhail Khovanov and IAS Member Louis Crane. Finally, around the year 2000, Khovanov created what is now known as Khovanov homology—a refinement of the Jones polynomial in which the knot is a physical object in four spacetime dimensions rather than the path of a point particle in a spacetime of only three dimensions.

Khovanov homology is like the Jones polynomial in that once it was invented, it could be computed by an explicit set of rules, though these rules are far more sophisticated than the ones that go into the Jones polynomial. I do not think that one would try to explain the definition of Khovanov homology to high school students.



ANDREA KANE

Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, first came to the Institute as a Member in 1984 and was appointed as a Professor in 1987. His work has significantly enriched the fields of mathematics and physics, and he has contributed greatly to the modern interest in superstrings as a candidate theory for the unification of all known physical interactions. Most recently, he has explored quantum duality symmetries of field theories and string theories, opening significant new perspectives on particle physics, string theory, and topology. A video of a talk that Witten gave to the Friends of the Institute for Advanced Study on quantum theory and knots is available at http://video.ias.edu/witten-friends.

Khovanov homology has had a great deal of impact mathematically. For example, it was a major topic in a special program in the School of Math at the Institute a few years ago.

One does not need quantum physics to define Khovanov homology, though one may need quantum physics to understand what it means. Indeed, in 2004, the physicists Sergei Gukov, Albert Schwarz, and Cumrun Vafa proposed a quantum interpretation of Khovanov homology, based on the earlier work of Vafa with Hirosi Ooguri. (These physicists are all former IAS Members and/or students.) Their story used plenty of avant-garde ideas about quantum fields and strings and all that.

As beautiful and powerful as their story is, I've always suspected that there might be a more direct route, and I spent the last year trying to construct one. Though in a sense I succeeded, I am not sure whether to say that I found a more direct route or just a somewhat different one.[1]

The main difference between Khovanov homology and the Jones polynomial is that the goal of Khovanov homology is more abstract. While the Jones polynomial of a knot K is a number J_K, the Khovanov homology of K is a "space of quantum states" known as H_K. If you think of a knot as a physical object in three-dimensional space, then H_K is the space of its possible quantum states.

Because Khovanov homology is in four spacetime dimensions rather than three, it involves ideas that are even closer to real particle physics than those that go into understanding the Jones polynomial. One important idea is symmetry between electric and magnetic fields. This is called electric-magnetic duality, and was pioneered in the 1970s by Peter Goddard (current Director of the Institute), Jean Nuyts, and David Olive (all former IAS Members). Since the mid-1990s, it has been one of the main tools in studies of quantum fields and strings, at the Institute and elsewhere. The use of electric-magnetic duality is actually crucial in circumventing the obstacle that had convinced me twenty years ago that Igor Frenkel's idea could not work.

Another facet of string theory also turns out to be important: extra dimensions. Even though what we want is supposed to be a theory in four spacetime dimensions, it turns out that understanding it properly involves relating it to theories in five or six dimensions.

The biggest surprise of all is that even though it can be defined by an explicit recipe with no reference to quantum physics—and that is how it was discovered—Khovanov homology can be understood, possibly much better, using the most modern tools of quantum field theory and string theory. Probably the full story involves physics ideas that we still do not entirely understand even today. ■

1 Edward Witten, "Fivebranes and Knots," http://arxiv.org/abs/1101.3216

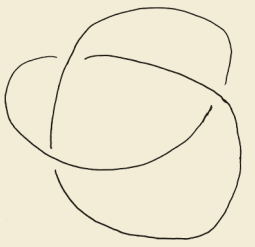


Figure 7

Some More Mathematical Details

To define the Jones polynomial (or actually a generalization of it called the HOMFLYPT polynomial) using the sort of relation described in the text, we really should introduce three variables a, b, and c and consider a general identity $a\,J_K + b\,J_{K'} + c\,J_{K''} = 0$. By virtue of this identity (and the normalization that $J_K = 1$ for an unknot), J_K turns out to be a homogeneous, rational function of the three variables.

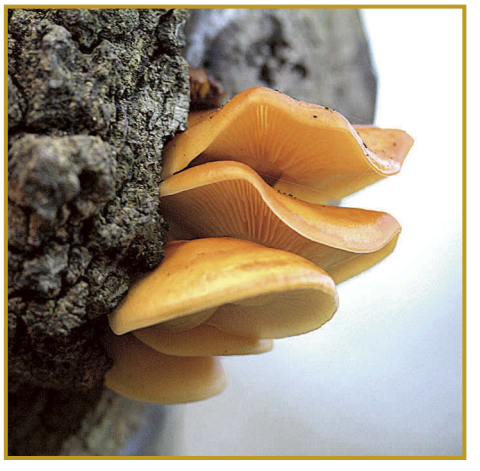
J_K is defined for a link (a disjoint union of embedded circles in three-dimensional space) and not only for a knot (a single embedded circle). In general, some or all of K, K', and K'' may have more than one component. In the original Jones polynomial, the knots and links are unoriented, as shown in the illustrations that accompany this article, but in the general HOMFLYPT polynomial they are oriented.

The identity $a\,J_K + b\,J_{K'} + c\,J_{K''} = 0$ (for every triple K, K', K'' related as in Figure 4) suffices to determine the Jones polynomial of any link. This can be proved by induction in the number of crossings when the link is projected to two dimensions. For example, a knot with three crossings is sketched in Figure 7. In the special case $b=0$, the relation $a\,J_K + b\,J_{K'} + c\,J_{K''} = 0$ says that any two strands can be passed through each other while multiplying the Jones polynomial by $-c/a$. Of course, if strands can freely be passed through each other, we can untie any knot. For b nonzero, the relationship has an extra term, but this extra term reduces the number of crossings. So inductively, one reduces to the case that K is a link with no crossings at all—in other words, a union of s disjoint circles in the plane, for some s. A simple application of the identity $a\,J_K + b\,J_{K'} + c\,J_{K''} = 0$ shows that in this special case, $J_K = (-(a+c)/b)^{s-1}$.

The proof that the identity $a\,J_K + b\,J_{K'} + c\,J_{K''} = 0$ leads to a consistent result no matter how one applies it is less obvious, and is made by showing that the identity is consistent with certain relations among links that are known as the Reidemeister moves.

—Edward Witten

PHOTOS VLADIMIR VOEVODSKY



The Institute Woods: Photographs by Vladimir Voevodsky

An exhibit now on view at the Institute features photographs of the Institute Woods taken by Vladimir Voevodsky, Professor in the School of Mathematics, illustrating the remarkable diversity of its insect, bird, animal, and plant life. For information about the Woods, visit www.ias.edu/about/institute-grounds.

Oleg Grabar
1929–2011

Oleg Grabar, whose research over the past six decades has had a far-reaching influence on the study of Islamic art and architecture, died at the age of eighty-one on January 8.

Grabar, Professor Emeritus in the School of Historical Studies at the Institute, documented, interpreted, and extended the significance of Islamic art and history through extensive archaeological expeditions and research trips across the Islamic world in Africa, the Middle East, and Muslim Asia. The originality and range of his research and teaching made an enduring impression on the study of Middle Eastern culture, a field in which he posited questions that challenged Western perspectives. He was largely responsible for the growth in numbers of historians specializing in the history of Islamic art in the United States.

ANDREA KANE

Oleg Grabar (left) at the Institute's eightieth anniversary celebrations in November

"Oleg Grabar was a profound, prolific, and influential scholar who has been an essential part of the Institute community throughout the last two decades," Peter Goddard, Director of the Institute, noted. "We will greatly miss his generosity of spirit, playful humor, and vital presence."

Giles Constable, Professor Emeritus in the School of Historical Studies, who was a classmate of Grabar's at Harvard University and a colleague both at Harvard and the Institute, commented, "Oleg Grabar was an admired colleague and beloved friend, whose far-ranging mind, vivid character, and strongly held views contributed to any discussion in which he took part. He was in every sense a life-enhancing personality. Through his teaching and publications he left an indelible mark on almost every aspect of the study of Islamic art and architecture. The Institute, and Princeton, will not be the same without him."

Grabar's appointment to the Faculty of the Institute in 1990 brought Islamic studies to the School of Historical Studies, and over the past two decades he drew both emerging and established scholars to the Institute. In November 2010, he was awarded the Chairman's Award by the Aga Khan Award for Architecture for his lifetime achievement in widening and enriching the understanding of the Islamic world's architecture, emphasizing its geographical and chronological diversity, as well as positioning it within wider political, social, cultural, and economic contexts.

Grabar was born in Strasbourg, France, on November 3, 1929. His father André Grabar was an international expert of Byzantine art who published over thirty books on the early and medieval art of Bulgaria, Crete, France, Italy, and Turkey. "Intellectual activity came almost with the cradle," Grabar recalled in 1995, "and throughout my formative years I was surrounded by books." Grabar received a *certificat de licence* in Ancient History from the University of Paris in 1948. In 1950, he graduated magna cum laude with a B.A. in Medieval History from Harvard University and received two additional *certificats de licence* from the University of Paris in Medieval History and Modern History. Grabar continued his education at Princeton University, where he developed his interest in Islamic art, obtaining an M.A. (1953) and a Ph.D. (1955) in Oriental Languages and Literatures and the History of Art.

Upon earning his Ph.D., Grabar obtained a teaching position at the University of Michigan, where he became a full Professor in 1964. He was Honorary Curator of Near Eastern Art for the Freer Gallery of Art of the Smithsonian Institution (1958–69) and Director of the American School of Oriental Research in Jerusalem (1960–61), where he later served as Vice President (1967–75). In 1969, Grabar was appointed Professor at Harvard University, where he taught for twenty-one years. He was Chairman of the Department of Fine Arts from 1977–82 and held the post of Aga Khan Professor of Islamic Art and Architecture from its inception in 1980 until 1990, when he retired from Harvard to join the Faculty of the Institute.

Grabar was the author of some twenty books and more than one hundred and twenty articles in leading journals. His first book, *The Coinage of the Tulunids* (1957), focused on the ninth-century dynasty in Islamic Egypt. His landmark study *The Formation of Islamic Art* (1973), which has been translated into German, Spanish, and Turkish, with expanded editions in French and English, presented an original and imaginative approach to the complex problems of understanding Islamic art.

Grabar traveled extensively throughout the Islamic world and was Director from 1964–72 of the excavations at Qasr al-Hayr al-Sharqi—a medieval Islamic town partially buried under the sands of Syria in a region previously not thought to have had a significant history of human habitation. Work at the site resulted in a number of articles and ultimately a collaborative two-volume book, *City in the Desert, Qasr al-Hayr East* (1978), with Renata Holod, James Knustad, and William Trousdale. The research resulted in a groundbreaking interpretation of the original constructions, dating from the first half of the eighth century.

Epic Images and Contemporary History: The Illustrations of the Great Mongol Shahnama (1980), coauthored with Sheila Blair, marked the first publication of an early fourteenth-century manuscript, which was meticulously reconstructed by Grabar and Blair. In 1987, nearly thirty years of collaboration between Grabar and Richard Ettinghausen was published in the highly regarded survey *The Art and Architecture of Islam 650–1250*.

During his time at the Institute, Grabar was able to devote himself fully to research, writing, and travel, and he published prolifically within the realm of Islamic art, architecture, and culture. In *The Mediation of Ornament* (1992), he examined the role of decoration as mediator between the viewer and the object itself. His *The Shape of the Holy: Early Islamic Jerusalem* (1996) employed computer modeling to present a detailed architectural history of the city in a new way. That same year, *The Dome of the Rock* (with Saïd Nuseibeh) was published as a comprehensive visual documentation of one of the holiest places for Muslims, Christians, and Jews (this structure was an ongoing source of intrigue for Grabar, who in 2006 published a book of the same title). He was remarkably prolific even after his retirement in 1998, continuing to write or edit more than ten volumes. With Glen W. Bowersock, Professor Emeritus in the School of Historical Studies, and Peter Brown of Princeton University, Grabar edited *Late Antiquity: A Guide to the Postclassical World* (1999), which quickly became a standard resource for scholars and the general public alike. *Mostly Miniatures: An Introduction to Persian Painting* (2000) provided a thorough historiography of Persian painting. Much of Grabar's scholarly output was captured through eighty-three articles gathered in four volumes under the title *Constructing the Study of Islamic Art* (2005–06). His final book, *Masterpieces of Islamic Art: The Decorated Page from the 8th to the 17th Century* (2009), elucidated a wide range of illuminated manuscripts from museum collections around the world and was awarded the World Book Prize for the Book of the Year of the Islamic Republic of Iran in 2011. (For Grabar's personal reflections on his sixty years of scholarship, see the fall 2010 issue of the *Institute Letter*.)

Grabar's work earned wide recognition throughout his career, including the College Art Association Distinguished Lifetime Achievement Award for Writing in Art (2005), the Charles Lang Freer Medal (2001), and the University of California, Los Angeles, Giorgio Levi Della Vida Medal (1996). From 1957–70, Grabar was Near Eastern Editor of *Ars Orientalis*, a scholarly journal on Asian art and archaeology, and he was founding editor of the journal *Muqarnas* from 1979–90. He was a member of the American Academy of Arts and Sciences, the American Philosophical Society, and the Medieval Academy of America; an honorary member of the Austrian Academy; a corresponding member of the Académie des Inscriptions et Belles-Lettres of the Institute of France; and a corresponding fellow of the British Academy.

Grabar is survived by his wife of fifty-nine years, Terry Grabar, a retired professor of English, and his son Nicolas, daughter-in-law Jennifer Sage, and grandchildren Henry, Margaret, and Olivia of New York. His daughter Anne-Louise predeceased him in 1988. ■

DINAH KAZAKOFF

CLIFF MOORE

RANDALL HAGADORN

Oleg Grabar was remarkably prolific and engaged in the life of the Institute even after his retirement in 1998. He is pictured at left at a seminar in 2008, center at a public lecture in 2008, and at right at a School of Social Science seminar in November with Member Rita Chin (left) and Joan Wallach Scott, Harold F. Linder Professor (center).

DEBORAH KLIMBURG-SALTER

The excerpts below are from a blog (memoryog.tumblr. com) created in Oleg Grabar's memory.

Working for Oleg was a pure delight. Not only was it intellectually stimulating, but also fulfilling and rewarding on the personal level. He made me feel I was working with him rather than for him. He was supportive, understanding, and encouraging. He gave credit where credit is due. He took on his share of the work, and made sure to never overload those working for him with chores. No task was beneath him so as to relegate to an assistant. I often found myself asking him to give me more work.

Mohammad al-Asad, Center for the Study of the Built Environment; Research Assistant, School of Historical Studies, 1991–93

Oleg, of course, can be described and praised at endless length as an incomparable scholar, teacher, and mentor. Everybody in the field of Islamic art and culture owes him. But he was much more than that for many of us. For beyond his almost prophetic intellectual aura, he had this extremely rare quality: generosity, an immense generosity of himself. His capacity of loving people and understanding them in their profound nature in a disinterested manner was incredible, particularly in a professional world that favors egocentrism and self-promotion.

Valérie Gonzalez, École Nationale Supériure d'Architecture de Marseille; Member, School of Historical Studies, 1996–97

On December 10, 2010, Oleg and I spent a delightful afternoon in Princeton, belatedly celebrating the publication of the Paris Kitab al-diryaq facsimile. We chatted for a while in his home office before heading out for lunch at the Institute for Advanced Study. I congratulated him on his recent lifetime achievement award, whereupon he handed me the presentation volume published by the Aga Khan Foundation. As we flipped through the collection of photos in the chapter devoted to his life's work, Oleg provided a running commentary. He was largely silent on the subjects of career milestones, publications, and professional accolades. Instead, he reminisced about his students and their shared adventures.

Jaclynne Kerner, State University of New York at New Paltz

When he began to introduce us to the mysteries of art history, of Islam, of Muslim cultures, of complexity of societies and their history, and asked what seemed to be extraordinary questions, we were awoken to new systems of imagination, of connections and interdependencies, in short, to a whole new procedure of thinking and learning. . . . It was not just Prof. Grabar's academic teaching and guidance in the visual culture and history of art of the Muslim world; he also taught us a whole new relationship between teacher and student, one filled with humanity and bigheartedness.

Ülkü U. Bates, Hunter College

As your research assistant at the IAS for two years (1998–2000), I suddenly had the sort of resources and time at my disposal that I had not had since finishing my dissertation late in 1995, AND I had the office next door to you. And you were always available to chat or to have tea or take me to lunch, or to discuss the lecture we had just heard at lunch. . . . None of this that I have said, of course, communicates the sheer, day-to-day pleasure of sticking my head into your office and chatting about this or that, scholarly or not, of sharing jokes and gossip and observations about things both lofty and mundane . . . in short, of the enjoyment (and, of course, the inevitable taking for granted) of the company of a dear friend.

Cynthia Robinson, Cornell University; Research Assistant, School of Historical Studies, 1998–2000

Hackers, Liberalism, and Pleasure

CLIFF MOORE

BY GABRIELLA COLEMAN

Generally a hacker is a technologist with a love for computing, and a hack is a clever technical solution arrived at through non-obvious means (alternatively, it can mean a downright clunky and ugly solution, one, however, that gets the job at hand done). It doesn't mean to compromise the Pentagon, change your grades, or take down the global financial system, although it can. Hackers tend to uphold the values of freedom, privacy, and access; they tend to adore computers—the cultural glue that binds them together. They are trained in highly specialized and technical arts, including programming, system administration, and security research. Many hackers use their skills at work but also spend a fair bit of time tinkering, building, and exploring outside labor demands. Some gain unauthorized access to technologies, though the degree of illegality greatly varies (and most hacking is completely legal). They tend to value playfulness and cleverness and will take most any opportunity to perform their wit through code or humor or even both: funny code.

One important aspect of hacking is the development of free and open-source software, such as Firefox and Linux. Now a techno-social movement, the hackers make the underlying directions of software, known as source code, legally accessible via novel licensing schemes, such as the GNU General Public License. Other variations have focused on cryptography and privacy. The "hacker underground" has brought into being a politics of transgression by seeking forbidden fruit—and it is this variant that has received the lion's share of media attention.

A quick review of the language hackers frequently invoke to describe themselves or make ethical claims—freedom, free speech, privacy, the individual, meritocracy—reveals that many of them unmistakably express liberal commitments. "We believe in freedom of speech, the right to explore and learn by doing," explains one hacker editorial, "and the tremendous power of the individual."

By liberal, I don't only mean a political party. Nor do I mean simply an identity that follows from being a card-carrying member of the ACLU or the Electronic Frontier Foundation. Here I take liberalism to also embrace a set of moral and political commitments: protecting property and civil liberties, promoting individual autonomy and tolerance, securing a free press, ruling through limited government and universal law, and preserving a commitment to equal opportunity and meritocracy. These principles are realized institutionally and culturally in various locations and contexts, including on the Internet and most especially with computer hackers. Hackers traverse a range of morally laced themes such as access, privacy, freedom, law, expressive activity, individualism, transgression, the social good, and sharing, of which free software and open source is just one example.

Hacking, however, cannot be reduced to liberalism alone, for it does not fully capture and exhaust the emotional aspects that hackers experience, most notably deep pleasure. Hacking is characterized by an odd confluence of occupational (and pretty constant) frustration and personal/collective joy. As I routinely observed during my fieldwork, hacking—whether in the form of programming, debugging (squashing errors), or running and maintaining systems (such as servers)—is nothing but (consistently) frustrating. Computers/software are *constantly* malfunctioning, interoperability is often a nightmare to realize, users are often "clueless" about the systems they use (and thus break them or require constant help), the rate and pace of technological change is relentless, and meeting customer expectations is nearly impossible to pull off predictably.

Despite the endless parade of frustrations, hackers always seem to derive pleasure from hacking (which sits in marked contrast to academics, who often seem to do everything possible to avoid writing). In its more mild form, hacker pleasure approximates Aristotelian eudaimonia, pleasure that prioritizes human flourishing through the development of skills and capacities. In pushing their personal capacities through tinkering with and making technologies, hackers experience the joy that follows from the self-directed realization of skills, goals, and talents.

Hacker pleasure, however, is not always so staid and controlled. Less occasionally, but still with notable frequency, hackers experience a more obsessive and blissful state, a pleasure so complete, engrossing, and enveloping, it has the capacity to obliterate self-awareness. In native hack-jargon, this state of bliss is the "deep-hack mode." Matt Welsh, a well-known hacker and computer scientist, describes the utter magnetism of this mode: "very few phenomena can pull someone out of Deep Hack Mode, with two noted exceptions: being struck by lightning, or worse, your *computer* being struck by lightning."

Because hackers often submit their entire will and being to technology—and are famous for denying their bodies sleep, at least for short periods of time, to do so—the pleasure they derive is at times experienced as transcendent bliss. In these moments, utility is exceeded so that the self can at once express its most inner being and collapse within the objects of its creation. In the aftermath of a particularly pleasurable moment of hacking, there is no autonomous liberal self to be found.

Thus, utility is not the only driving force in hackers' creative acts. Although hackers are fiercely pragmatic and utilitarian—technology after all must work and work exceptionally well—they are also fiercely poetic and repeatedly affirm the artistic elements of their work. A concrete expression of technology/software as art is when source code is written as poetry or alternatively poetry is written in source code. For many free-software hackers, the act of writing software and learning from others far exceeds the simple enactment of an engineering ethic or a technocratic calculus for the sake of becoming a more proficient and efficient programmer or system administrator. Software development and related technical activities are construed as valuable avenues for highly creative forms of expression, even if they openly admit to various constraints.

Presenting hacking in terms of liberalism and pleasure gets us closer to what makes this site of ethics and technological production so intriguing. Because the joy of hacking intimately shapes the hacker desire for productive freedom, hacker pleasure forms part of the ground for adopting and extending liberal commitments. The unruly, deeply felt pleasures of hacking, which at times stray from liberal visions, hold a substantive link with them. ■

Gabriella Coleman, an Assistant Professor of Media, Culture, and Communication at New York University, is the 2010–11 Ginny and Robert Loughlin Founders' Circle Member in the School of Social Science. Trained as an anthropologist, Coleman examines the ethics of online collaboration and institutions as well as the role of the law and digital media in sustaining various forms of political activism. Between 2001–03, she conducted ethnographic research on computer hackers primarily in San Francisco and the Netherlands, as well as those hackers who work on Debian, a free-software project.

demand the right to work and the right to free expression.

Certain questions remain enigmatic when it comes to revolutions in general and to the Tunisian revolution in particular: How is a revolution born? What are the causes from which a revolution originates, the mechanisms whereby it is triggered? How does one move from claims and protests to revolution? The matter is even more mysterious when one considers the Tunisian revolution. How is it, for instance, that the Tunisian people, long silent under the burden of oppression, suddenly rose in revolt? This revolution was unexpected. It surprised everybody, including the very actors involved in it and those who led it. There are revolutions, in other words, but there is no theory of revolution. The Tunisian example will have to be studied the way one studies the French revolution, the Russian revolution, and so forth, and taught for what it is in itself, for its *singularity* and its *exemplarity*.

IN THE TUNISIAN REVOLUTION, THE YOUTH, MOST PARTICULARLY THE UNEMPLOYED EDUCATED, PLAYED A CRUCIAL ROLE, FIRST IN TRIGGERING THE DEMONSTRATIONS, AND THEN BY SUSTAINING AND STRENGTHENING THE REVOLT.

Over the course of General Ben Ali's rule, the minimal conditions did not exist to exercise citizenship, political engagement, or union activism. The regime controlled everything and left no possibility open for expressing any discontent. Public opinion was muzzled and censorship was omnipresent.

Ben Ali's hold on power and exercise of it had become increasingly centralized and personalized, reducing to the barest minimum the role and function of the political institutions (parliament was no more than a recording chamber), the juridical apparatus (the courts were at the order of the dictator, with unjust trials and verdicts), and the public administration (corruption, nepotism, and so forth). The omnipotence of the executive branch was crushing the country and stifled all political play, reducing all forms of plurality to naught. The president's party (the "Constitutional Democratic Rally" or RCD) was essentially the state, and its interests came before the general interest. The state served the increasing private wealth of the president and the family of his wife, which constituted, according to the American ambassador in Tunisia, a "quasi-mafia." The president of the RCD was the President of the Republic, and he named all the members of the political leadership, from the federations to the local sections of the party.

All this led to the frustration of a population that was constantly subjected to intimidation, to the most blatant forms of injustice, and to feeling increasingly offended, yet with no outlet to express any discontent. No one could denounce injustice or call for justice to be done. The well-policed system of control had managed to normalize an entire society, using the most cruel means of repression: no respect for the most basic rules of law, the fabrication of false evidence, iniquitous judgments, defective legal procedures, harsh sentences, and of course torture, the use of which was rampant.

External observers often pointed to the relative economic success of the Tunisian state. Some went so far as to speak of a "Tunisian miracle" with an alleged growth rate of 4 to 5 percent. In fact, this was known to not be true. Additionally, it was known that the relative economic prosperity of the country only benefited a small minority, who enjoyed exorbitant fiscal privileges and made massive use of illegal means in order to rob public goods and the resources of the land. Important public enterprises were privatized and sold at derisory prices, private enterprises were created and financed with public funds, and so forth. What ensued was that a wealthy minority (around 10 percent of the population) disposed of a third of the GNP, whereas the poorest Tunisians (30 percent of the population) had to make do with less than a tenth of the GNP. Unemployment affected 15 to 20 percent of the population, and among educated youth it reached 30 percent.

Beyond social inequalities, there were also regional inequalities and disparities. Indeed, economic development, real-estate investment, and tourism were all concentrated around the capital, Tunis, and the coastal regions of the northeast and of the Sahel. The interior regions remained rural zones of extreme poverty disproportionately affected by unemployment; whence a profound sense of injustice that was constantly manifested by the inhabitants of these areas. It is no accident that the demonstrations and the demands made by protestors emerged from Sidi Bouzid, a disfavored, rural, and poor region in the interior.

Where is justice in all of this? Why did the Tunisian demonstrators deploy such strong slogans: "Freedom," "Work," and "Dignity"? These slogans have received a considerable echo among the population, mobilizing individuals everywhere, in all the cities, towns, and regions. Such are the first questions that come to mind when seeking to understand the themes and motivations that were at the origin of this "spontaneous" revolution.

In Tunisia, there was an undeniable problem of distributive justice: all Tunisians did not benefit from economic development. A privileged group monopolized the resources of the country. For a short while, the middle class was able to draw some advantages from economic growth, but the recent economic crisis rendered its buying power more fragile and uncertain.

ALSO CRITICAL WAS THE FUNCTION OF NEW TECHNOLOGIES OF INFORMATION AND COMMUNICATION, AND OF SOCIAL NETWORKS SUCH AS THE INTERNET, FACEBOOK, AND TO A LESSER EXTENT TWITTER.

Where the rule of law and the most elementary moral values are transgressed or violated, where gestures and signs of deference, of consideration, and of respect are neglected, and where the dignity of individuals is denied, then justice has been replaced with injustice. Indications of understanding and of contentment, signs of approval or acceptance are transformed into screams of indignation, into gestures of denunciation, into protest and revolt. The cry "It is unjust!" demands access into the domain of law. Justice presupposes the principles of respect and of dignity, whereas injustice engenders humiliation and contempt.

According to Ernst Bloch, "the so-called sense of justice . . . often reveals itself as composed of the most diverse feelings and emotions." The explosion of anger in Tunisia provides an opportunity to discern what enters into the mix, what elements compose the drive for justice. Imperatives of impartiality, equality, and merit are one aspect of justice, as is the exigency of respect and dignity for the human being as such, independently of his or her social class or regional belonging. It is impossible in just a few pages to exhaustively cover the importance of all the elements that compose the idea of justice. I will limit myself therefore to an analysis of the central role of respect and of dignity in guaranteeing a true social justice.

The concept of respect is surely very complex. One could say that it is ambiguous and polysemic. It is proximate to esteem, consideration, and deference. Further, it involves rights as well as persons. The imperative is to recognize the individual person as having inalienable rights and obligations.

The most evident link between justice and respect appears quite clearly in the work of John Rawls, for whom the notion of respect occupies a central place in his theory of justice as equality. According to Rawls, respect is a basic condition that is guaranteed by the principles of justice in a well-ordered society. What is at stake is in fact "self-respect," considered to be a primary good, perhaps the most important good in Rawls's eyes. Hence, "a desirable feature of a conception of justice is that it should publicly express men's respect for one another."

In order to analyze in more depth the question of respect, it is important to distinguish "self-respect" from "self-esteem." This distinction is important for someone like Paul Ricoeur who argues in *The Just* both that "there is a bond of mutual implication between self-esteem and the ethical evaluation of those of our actions that aim at the 'good life,'" and that "there is a bond between self-respect and the moral evaluation of these same actions, submitted to the test of the universalization of our maxims of action." Thus, Ricoeur continues, "taken together, self-esteem and self-respect define the ethical and moral dimension of selfhood, to the extent that they characterize human beings as subjects of ethico-juridical imputation." Ultimately, "we ourselves are worthy of esteem or respect insofar as we are capable of esteeming as good or bad, or as declaring permitted or forbidden, the actions either of others or of ourselves."

Ricoeur's distinction could prove useful toward understanding better the reaction of the Tunisian population that was offended and humiliated by an oppressive regime, which totally failed to demonstrate respect and consideration. Indeed, Ricoeur argues, self-respect must be considered as "the fact of defending one's rights, to resist everything that can trample them, to refuse to be used, manipulated, exploited or degraded." Self-respect, when dismissed or denied, incites one to refuse all humiliation and provokes indignation, protest, and revolt.

AFP/GETTY IMAGES

The army did not intervene in the Tunisian revolution, nor were there actions of an organized rebellious faction.

From these limited reflections, I would propose an understanding of social justice that always involves what I would call an *ethics of respect*: respect of individual and collective rights, respect of procedures, and so forth. This ethics of respect must be found at the basis of any social contract, of any political pact capable of grounding

ASSOCIATED PRESS

The Tunisian people first made a claim for their fundamental right to freedom, to respect, and to dignity.

a democratic regime, and of any state with a rule of law worthy of that name.

The Tunisian revolution has shown that respect necessitates the establishment of political institutions that will guarantee the protection of dignity and the fundamental rights of citizens. One of the major lessons of this revolution is that the Tunisian people, prior to demanding economic, social, or cultural rights, first made a claim for their fundamental right to freedom, to respect, and to dignity. The basic right to be respected is the necessary condition enabling each Tunisian citizen to establish him or herself as a subject of rights, for him or her to be considered as a person capable of participating in the construction of a political space in which equality and "difference" (*ikhtilâf*) are both legitimated and guaranteed by the rule of law.

THE NEW TECHNOLOGIES PROVIDED AN ENVIRONMENT FOR THE EXERCISE OF CRITIQUE WITH A TEMPORALITY (REAL TIME) AND A VIRTUAL LOCATION (THE NETWORK) THAT ESCAPE TRADITIONAL FORMS OF CONTROL AND OF CENSORSHIP. FROM THE BEGINNING, THOUSANDS OF INTERNET USERS PARTICIPATED IN THE LAUNCH OF PROTESTS AND IN THE ORGANIZATION OF DEMONSTRATIONS.

Freedom is first of all a conquest—such is one of the major lessons to draw from the Tunisian revolution. However, once won, freedom must be exercised and put to the test of reality. This requires the elaboration of a legal order, which determines the conditions of freedom's exercise and the spheres within which it can be realized. At stake are in fact borders. Freedom ends where the freedom of others begins, as the old saying goes. The drawing of borders between the different powers (executive, legislative, and judiciary), between the sphere of the state and that of the ruling party or civil society, follows a similar logic. This *art of separation* must be institutionalized, but it requires consultation and public debate, as well as a collective learning, all of which constitute the necessary conditions to establish the rule of law.

But what precisely is the role that law must play in order to ensure the transition from an insurrectional situation toward a process of democratic transition?

One knows that the legal order of the old regime has been *de facto* revoked. That is a consequence of the revolution. The entirety of its juridical apparatus must therefore be put in question, because it has completely lost its legitimacy, because it was established on an unjust basis and unjust principles. The constitution, the electoral law, the law of the press, and more have all served the dictatorship and its staying power instead of the general interest or the popular will. That is why it is necessary to dismantle the juridical apparatus in order to build, from the ground up, a new and just legal order that will draw its legitimacy from the principles of the revolution. That is the task assigned to the High Commission for Political Reform, at the head of which is the Tunisian jurist Yadh Ben Achour.

The new legal order also must not be severed from the social order, which is by definition heterogeneous and affected by many kinds of contradictions, differences, and struggles. These must be translated in order for the law to be legitimate. What is therefore required is a *new social contract* and a *new political covenant*, which must assume and ratify these differences, and which must involve the elaboration of viable political compromises that include all political groupings, all movements, all components of society.

The process of transition requires the institutionalization of conflict, the establishment of new legitimate powers, and the definition of new rules for the political game: procedures of universal suffrage founded on the sovereignty of the people, the selection of the voting system toward the organization of elections (majority or proportional representation), the nature of the political regime (presidential, parliamentary), and so forth. All these questions must be the object of contradictory debates, consultations, and compromises involving the entirety of the nation's living forces, and not a limited coterie of technocrats or experts (no matter how competent).

And yet, one cannot help but notice that there remain many zones of opacity in the current process of transition. For it requires the shaping of a juridical form in order to institutionalize the gains of the revolution and to determine the new sites of power. Based on the available information, some of the first decisions made by the provisional government failed to involve any true consultation. For example, the nomination of the new governors was the result of a unilateral decision by the Interior Minister. Similarly, the nominations of some ambassadors by the Foreign Affairs Minister were performed in a spirit of continuity with the old regime. In both cases, and in others as well, such decisions have provoked an angry reaction from the population: people have expressed their opposition with protests and demonstrations. In some regions, they gathered in front of the governors' offices in order to demand the immediate departure of newly named governors. They succeeded. Following his own strong positions (and probably to appease the tensions), the Interior Minister decided to "freeze the activities of the RCD" until its dissolution by legal judgment, according to the required procedure.

It seems clear (as I write this) that the popular will continues to play its role as a counter-power in order to preserve the gains of the revolution and to change the anti-democratic practices of the old regime. One can only hope that these practices of resistance continue to accompany the process of transition, in order to ensure the passage from revolution to a truly democratic rule of law. The future of the revolutionary process will depend on the popular will and its readiness to exercise control over the choices and the orientations (institutional, political, economic, etc.) that will be ratified over the course of this transition period.

FACEBOOK ENABLED THE INSTANTANEOUS DIFFUSION OF INFORMATION AND, THROUGH TESTIMONIALS AND AMATEUR VIDEOS, IMAGES OF THE REPRESSION AND THE FACES OF VICTIMS. THE INTERNET PERMITTED PROTESTORS TO TRANSCEND REGIONAL ENCLOSURES, TO WIDEN THE MOVEMENT, AND TO GIVE THE REVOLUTION A NATIONAL AND EVEN INTERNATIONAL DIMENSION.

The revolution turned out to be a formidable moment in the quest for freedom and for dignity. In the transition from revolution to the exercise of freedom and of democracy, law must play a crucial role. There were no doubt abuses and failures with regard to law, but overall the Tunisian people were careful to act within a legal frame, while advancing a new, revolutionary legitimacy.

Let us hope that the Tunisian people will walk on the path of freedom and of dignity without falling by the wayside, or suffering that which they have already suffered enough. ■

Translated by Gil Anidjar, Member in the School of Social Science and Associate Professor of Religion and Middle Eastern, South Asian, and African Studies at Columbia University

Born and educated in Tunisia, Mohamed Nachi is Professor of Sociology at the Université de Liège, Belgium. He is currently a Member in the School of Social Science at the Institute for Advanced Study. Trained as an anthropologist and a sociologist, his expertise is pragmatic sociology, specializing in Islam and Islamic thought. His most recent book is Actualité du compromis. La construction politique de la difference [The Relevance of Compromise: The Political Construction of Difference] *(A. Colin, Paris, 2011). Nachi, whose family still lives in Tunisia and who is in daily contact with friends and colleagues there, is grateful to Joan Wallach Scott, Harold F. Linder Professor in the School of Social Science, for organizing a conversation at the Institute about the situation in Tunisia in January 2011, and for suggesting the publication of this essay.*

1948–1950: Snapshots

BY CÉCILE MORETTE, ÉPOUSE DEWITT

In Brief

It all began with a cable from Oppenheimer that I received on March 10, 1948, in Trondheim, Norway: ON THE RECOMMENDATION OF BOHR AND HEITLER I AM GLAD TO OFFER YOU MEMBERSHIP SCHOOL OF MATHEMATICS FOR THE ACADEMIC YEAR 1948 – 1949 WITH STIPEND OF $3500. ROBERT OPPENHEIMER.

I did not know that this was a great offer. I did not even know where Princeton was, but as a general rule, I would rather say "yes" than "no." I was then on leave from the French Centre National de la Recherche Scientifique (CNRS), having been awarded a Rask-Oersted Fellowship for the academic year 1947–48 at the Nordiska Institutet för Teoretisk Fysik in Copenhagen.

INSTITUTE FOR ADVANCED STUDY

Cécile DeWitt-Morette with (from left to right) Isadore Singer, Freeman Dyson, and Raoul Bott at the Institute in the 1950s

In retrospect, I think that in the days of the Marshall plan, Oppie was looking for a couple of European young postdocs who would benefit from a year at the Institute. Did I benefit? More than I could ever have imagined.

During my two-year stay, 1948–50, Bryce DeWitt, a postdoc at the Institute, 1949–50, asked me to marry him, and I conceived the Les Houches Summer School as my self-imposed condition for marrying a "foreigner." Thanks to Freeman Dyson and Richard Feynman, I learned about functional integration and am still fascinated by it.

My latest two books grew out of my stay at the Institute from 1948–50:

Functional Integration, Action and Symmetries (with P. Cartier), Cambridge University Press 2006.

The Pursuit of Quantum Gravity, Memoirs of Bryce DeWitt from 1946 to 2004, Springer 2011.

I hope that my article in the *Institute Letter* will reflect my debt to the Institute.

First Impressions

I came by ship, traveling first class, my stepfather having upgraded my CNRS travel allowance. He wanted to be sure that my traveling companions would meet his approval; he came on board the ship to choose my assigned table. It turned out to be a table of Dominican Fathers, but I was sick most of the time and hardly met them. As for meeting eligible young men, he had arranged for Bernard Gregory, then a graduate student at MIT, later to become Directeur Général of CERN, to look after me. He did. He came to Princeton to be my escort at the Institute's 1949 Spring Dance. He did not come in 1950.

Here are a few snapshots of my arrival:

- People would respond to my thanks with "You're welcome." I thought they all remembered Lafayette and were welcoming a compatriot of Lafayette.
- Along the road, I read "Slow men at work" as "Slow men, at work." I could not read it as "Slowly, men at work" because in school I had been taught that adjectives could not be used as adverbs. I concluded that people in the U.S. were very considerate of their handicapped workers.
- I saw a panel "Antiques, old and new." I knew that in France we sometimes sold copies as genuine antiques, but we did not publicize it. I concluded that people in the U.S. were incredibly honest.

I arrived at the Institute with a glowing picture of the United States. It was shattered when Oppenheimer greeted me as "Cécile." I was Cécile only to my family and closest friends; to anybody else, I was "Mademoiselle Morette." I felt violated and treated like a maid. Nowadays I am happy to be Cécile to everybody.

The Institute had reserved a nice suite for me at the home of the Frothingham's, 9 Ober Road. Shortly after I arrived, Mrs. Wigner asked me if I could spend the evening at their house. Having happily accepted, I found myself babysitting Martha, as the parents were leaving their home. I had never heard of babysitting. The worst was that the supper left for Martha consisted of a wienie and some carrot sticks; judged from the point of view of a French upbringing this was totally unacceptable for a toddler. In retrospect, I doubt that a recently arrived male postdoc would have been asked to babysit.

A French background is often a mystery to someone who has not lived many, many years in France. Who, for instance, understands the difference between an *Ingénieur des Mines* and an *Ingénieur au Corps des Mines*? An *Ingénieur des Mines* is a mine engineer. An *Ingénieur au Corps des Mines* is a top graduate from l'Ecole Polytechnique, France's most prestigious school (so say most people). An *Ingénieur au Corps des Mines*—for example, physicists like Bernard Gregory, Albert Messiah, Roger Balian—is not likely to be a professional mine engineer. One finds *Ingénieurs au Corps des Mines* in top positions in the public and the private sector.

Oppenheimer

Oppenheimer misunderstood my background. I would wear the same frock day in and day out. I sewed a new one when spring came. I did not know how to drive a car. When Oppie asked me if my father could drive a car, I simply said "no." My father (*Ingénieur au Corps des Mines*!) was the CEO of a large industrial complex, La Société Métalurgique de Normandie, and of an iron mine, Les Mines de Soumont. He had a chauffeur, and so did the family. Based on my appearance, Oppie assumed that I came from a disadvantaged family. Oppie and Kitty went out of their way to make me a woman of the world. When I realized the misunderstanding, it would have been unkind to correct the situation, and I happily remained their ward. It was not uncomfortable; it even had advantages:

- I was often invited for a martini at their house at the end of the day.
- For the 1949 Spring Dance, Bernard Gregory and I were the chosen couple invited to have supper at the Oppenheimer table.
- Oppie gave my name to C. M. G. Lattès, the Director of the Centro Brasileiro de Pesquisas Fisicas, who had asked Oppie to recommend a lecturer for the 1949 summer, the very year the Center was established. It was a great opportunity for me. Feynman had been invited. We lectured daily. This course is the basis of a book[1] I wrote at the Institute upon my return from Rio.
- Oppie invited me to stay for a second year at the Institute. He thought I was worried about returning to France. I had not told him that Laurent Schwartz had invited me to join the Université de Nancy as Maitre de Conférences, a tenured position; but this position could most likely be postponed.

Green Card

The first thing I did when I arrived in Rio during the 1949 summer was to apply for a green card. I was not planning to stay in the U.S.; I only wanted to make visits to the U.S. with less hassle. My green card was issued on September 17, 1949, and I remained a legal immigrant until April 26, 1999. Why did it take me fifty years to become a U.S. citizen? I simply did not want to say the Oath of Allegiance that restricted my French citizenship inappropriately. However, after examining more closely the situation, I decided that the best for me was to take the U.S. citizenship and to take steps to have the Oath of Allegiance reworded. (Copy of my correspondence with Congressman Lloyd Doggett is available upon request.)

The first new Member I saw when I arrived at the Institute for my second year, 1949–50, was a "Schwinger boy" and I was pleased to be able to lord my seniority over a Schwinger boy. His name was Bryce Seligman DeWitt.

Path Integrals

Two *Physics Today* articles capture very well life at the Institute in 1948–50:

- Freeman Dyson's letters to his family in November 1948[2];
- An interview by Toni Feder, "Path integrals, Les Houches, and other adventures of Cécile DeWitt-Morette."[3]

Dyson had invited me to spend a long weekend away from Princeton to visit Feynman at Cornell. This expedition is so well described in a couple of letters from Dyson to his parents that I cannot summarize it (see box, page 11). I was so enchanted by the path integral formalism presented by Dyson and Feynman in seminars they gave at the Institute during the fall of 1948 that I wanted to develop it from its magical (heuristic) beginning into a practical (mathematically robust) tool. My first paper on the subject, "On the Definition and Approximation of Feynman's Path Integrals,"[4] deals with:

- Volume elements in the infinite dimensional domain of integration;
- The expansion of the action functional around its value for a classical path, i.e., the background method, WKB approximations, and beyond;
- Paths taking their values in spacetime.

In its original form this paper was easier to read, but Oppenheimer suggested excisions of well-known remarks (but new to me!) that I did not handle very well. Of course it took many years and many people to develop the ideas presented in this paper, and the work is still on the drawing board.

"Siblings"

Life at the Institute was delightful. Sharing discussions in the corridors, at lunchtime, and at teatime created a warm and friendly atmosphere. Think of the young postdocs as siblings ready to help each other. I often needed help because in France at that time there was no graduate program and I had never attended a graduate course. I recall being tutored on group theory by my office mate, Bruria Kaufman, and on Lagrangian and Hamiltonian dynamics by Léon Van Hove. Help was not limited to physics. When, in the summer of 1949, Verena Haefeli mentioned her plan to drive to California with her young daughter Katrin and her colleague Kurt Reidemeister, the "siblings" urged me to accompany her. They overestimated my abilities and the engine blew up at Lake Tahoe: I did not know about checking oil.

During the 1948 Christmas break, I decided to visit the U.S. with a French friend, then an instructor at Smith College. (The excuse given to the Institute was

visiting the MIT cosmic ray lab at Echo Lake.) We felt that the only choice we had to make was to travel clockwise or counter-clockwise. We found ourselves in Houston dressed in skiing outfits ready for Echo Lake. In retrospect, this trip was hilarious. We felt very free, not knowing U.S. patterns of relationships and far away from our families. By the time they received our letters, the news was at least a week old, and their advice would not reach us for another week. Moreover, our families had a distorted vision of the U.S.; they were used to looking at French atlases where France and the U.S. are printed on the same size page. Stories of this 1948 Christmas trip are available upon request. Here I shall only recall a lovely dinner at Norman Kroll's parents' home in Houston. Norman was not there, but my Smith College friend was getting out of hand, and I needed to recreate a proper atmosphere so I called Norman's parents.

Being in a male-dominated Institute was no problem. I was not going to marry a foreigner (anyone who was not French!), and I was not cognizant of patterns of behaviors between young people in the U.S. Life for me was simple. I recall two episodes where the other postdocs considered me as a woman.

They wanted to know if I could cook, and Quin Luttinger asked me to prepare a meal for them. I did it, after having sent an emergency cable for a recipe to my friend at Smith College.

Jack Steinberger had organized an overnight hike and wondered about my sleeping accommodation. "No problem," said I. "I shall put a log between you and me." He still mentions this!

CLIFF MOORE

Cécile DeWitt-Morette with Freeman Dyson, Professor Emeritus in the School of Natural Sciences, at the Institute's eightieth anniversary events focused on the Schools of Mathematics and Natural Sciences in September

Cécile DeWitt-Morette is the Jane and Roland Blumberg Centennial Professor in Physics, Emerita, at the University of Texas at Austin. She founded L'École de Physique des Houches in 1951 and served as its Director for more than two decades. She is a member of the Conseil d'administration of the Institut des Hautes Études Scientifiques, an institution that she played a role in establishing (see box, below).

Les Houches

One of the other "siblings," Bryce DeWitt, had other views and, at the end of a day of canoeing, while we were having supper at my apartment, he asked me if I would marry him. My knee-jerk reaction (I had practice) was that I could not because he was a "foreigner." He then left my apartment and went back to physics. But I was sad, very sad. The next morning I had a sudden, fully formed thought: If I created a summer school in a little village in the French Alps where twenty people would come to learn recent developments in physics presented by the authors themselves, I would have done something for France, and I could marry Bryce. I rushed to the phone and asked a very sleepy Bryce, "Does your offer still hold?" "Which offer?" (Years later he told me that he had asked, not offered, hence he did not remember any offer!) I proceeded to tell him my plan to create what became the Les Houches School. He understood that I had something to do before getting married. "Sure, good night." (It was 7:30 a.m. for me; his bedtime.)

The school was officially created on April 18, 1951, and we were married on April 26, 1951. The rest has been told—or nearly. The idea of the school had come easily; there was a need, the need could be met if I marshaled the necessary collaborations, and if I found the money. I knocked at many doors. "*Elle emmerdera la terre entière mais elle l'aura*," Pierre Auger would say affectionately. I knocked at the door of Pierre Donzelot, then Directeur des Enseignements Supérieurs, having carefully planned to knock when his secretary would be at lunch. In the lobby, I had pretended to be a secretary so that no *factotum* would stop me. Donzelot opened his door. I told him my story. He offered the money right away.

My Debt

My debt to the Institute covers much more than these recollections of 1948–50. Seeds were planted then. They have grown since in a variety of activities. I refer to a few publications[5] for details.

I have a photo album rich in memories, but without captions! On top of the first page of the 1951 Les Houches photos, I have copied a phrase from a letter of Oppenheimer, but I have not kept the letter. Oppie's phrase has kept me going many decades. "In overcoming all the difficulties, in making of this school something whose high standards were made possible by love, and love fruitful by scholarship…." ■

1 *Particules Elémentaires* (Hermann, Paris, 1951)

2 *Physics Today* 42 (February 1989)

3 *Physics Today* 61 (August 2008)

4 *Physical Review* 81 (1951)

5 *Women in Chemistry and Physics: A Bibliographic Source Book*, edited by Louise S. Grinstein, Rose K. Rose, and Miriam H. Rafailovich (Greenwood Publishing Group, Inc., Westport, Conn., 1993)

Out of the Shadows, Contributions of Twentieth Century Women to Physics, edited by Nina Byers and Gary Williams (Cambridge University Press, 2006). See also the foreword by Freeman Dyson.

Les Déchiffreurs, by Jean-François Dars, Annick Lesne, and Anne Papillault (Editions Belin, 2008)

Dictionnaire des Créatrices, edited by Jean Schneider (Editions des Femmes, Paris, 2009)

Of Historical Note

Freeman Dyson, Professor Emeritus in the School of Natural Sciences, wrote a series of letters to his parents about Richard Feynman, published by *Physics Today* in 1989. Feynman visited the Institute but declined an offer to join its Faculty from J. Robert Oppenheimer, Director of the Institute at the time, because he considered the Institute to be "snobbish, stuffy, and scientifically sterile," according to Dyson (for more on Feynman's views of the Institute, see his autobiography, *Surely You're Joking, Mr. Feynman!*). Dyson mentions Cécile DeWitt-Morette in his letters, excerpts of which are below with Dyson's commentary in italics.

In the next letter a great woman appears, whose name was then Cécile Morette and is now Cécile DeWitt. She was in 1948 a member of the Institute for Advanced Study, having arrived from France via Dublin and Copenhagen. She was the first of the younger generation to grasp the full scope and power of the Feynman path integral approach to physics. While I was concerned with applying Feynman's methods to detailed calculations, she was thinking of larger issues, extending the path integral idea to everything in the universe including gravitation and curved space-times.

Boston, 1 November 1948

After my last letter to you I decided that what I needed was a long week-end away from Princeton, and so I persuaded Cécile Morette to come with me to see Feynman at Ithaca. This was a bold step on my part, but it could not have been more successful and the week-end was just deliriously happy. Feynman himself came to meet us at the station, after our 10-hour train journey and was in tremendous form, bubbling over with ideas and stories and entertaining us with performances on Indian drums from New Mexico until 1 a.m.

The next day, Saturday, we spent in conclave discussing physics. Feynman gave a masterly account of his theory, which kept Cécile in fits of laughter and made my talk at Princeton a pale shadow by comparison. He said he had given his copy of my paper to a graduate student to read, then asked the student if he himself ought to read it. The student said "No" and Feynman accordingly wasted no time on it and continued chasing his own ideas. Feynman and I really understand each other; I know that he is the one person in the world who has nothing to learn from what I have written; and he doesn't mind telling me so. That afternoon, Feynman produced more brilliant ideas per square minute than I have ever seen anywhere before or since. In the evening I mentioned that there were just two problems for which the finiteness of the theory remained to be established; both problems are well-known and feared by physicists….

When I mentioned this fact, Feynman said, "We'll see about this," and proceeded to sit down and in two hours, before our eyes, obtain finite and sensible answers to both problems. It was the most amazing piece of lightning calculation I have ever witnessed, and the results prove, apart from some unforeseen complication, the consistency of the whole theory.

The two problems were, the scattering of light by an electric field, and the scattering of light by light….

14 November 1948

Cécile amused us all yesterday by bringing down a French millionaire to see the institute (an industrial magnate of some kind). She said she hinted to him fairly strongly that France could do with an institute of a similar sort; she said if she were made director of the French institute she would invite all of us to come and lecture there. It will be interesting to see if anything comes of it.

The man Cécile brought to see the Princeton institute was Léon Motchane. Motchane later became the founder and first director of the Institut des Hautes Études Scientifiques at Bures-sur-Yvette in France. The IHÉS is a flourishing institution that has made a major contribution to the support of mathematics and theoretical physics in France. Cécile was 26 when she brought Motchane to Princeton and planted the seed that grew into IHÉS. A few years later she founded the Les Houches summer school, which is also a flourishing institution and has been a training ground for generations….

DNA, HISTORY, AND ARCHAEOLOGY *(Continued from page 1)*

Technological advances, scientific instrumentation, statistical analyses, and laboratory tests are today producing historical knowledge that aims to find new ways of answering questions that have long exercised specialists of the ancient world. Should historians, then, try to make these pieces of highly technical evidence relevant to their own work? Or should they ignore them? The dilemma is not entirely new. Archaeology, material culture, and historical linguistics have already forced historians to come out of the "comfort zone" of written sources. Archaeologists have by and large wrested themselves free from the fastnesses of the classical texts, and much of their work cannot be regarded as ancillary to the authority of the written word. Satellite photography, remote sensing, archaeo-GIS, C14 dating, dendrochronology (tree-ring dating), and chemical analysis have become standard tools of the archaeologist that coexist with the trowel and the shovel. But the palaeosciences and ancient DNA studies pose challenges of a different order, directly correlated to the greater distance that exists between scientific and historical research in terms of training and knowledge base.

The scientists today engaged in the "archaeosciences" are claiming an independent grip on the past. Specialized journals exude a wealth of information on plants, animals, and climates of the past, ancient pathologies, and the genetic makeup of long-gone peoples. These studies address unresolved questions about humans roaming the earth thousands of years ago, and possibly hold in the balance the solution to theories fiercely debated for decades and even centuries. Identifying the paths and patterns of human migrations and genetic distribution is a high priority.

There are several reasons why such issues remain important, and they are different for different researchers. I started to read ancient-DNA literature because I was interested in a simple question: how did the nomadic peoples of Asia form their empires? The wind-swept, arid, scarcely populated, and technologically backward regions of the central and northern steppe regions of Asia are unlikely places for the rise of powerful political formations. No historian so far has been able to explain satisfactorily the sudden appearance of the first steppe empire created by the Xiongnu (a.k.a. Asiatic Huns) on the doorstep of China in the late third century B.C.E. Its emergence has been thought to have connections with the barbarian invasions that, a few hundred years later, would contribute to the fall of the Rome. Later empires, regimes, and dynasties of steppe origin—Turks, Uighurs, and Mongols—had government institutions, legal systems, religious beliefs, imperial rituals, and a ruling ideology whose first political embodiment can be traced back to the same Xiongnu empire. Considering the whole of world history, who the Xiongnu were and how they became an empire are actually quite important questions.

In order to address these large issues one ought to look into the early history and prehistory of nomadic communities, understand how they lived, moved, adapted, and evolved socially and culturally, and try to figure out how they interacted with other peoples: trade or raid, tribute or conquest. Understanding the genetic legacy of peoples identified as Xiongnu can bear upon how we connect the dots between populations where unusual concentrations of wealth and power or centers of advanced technology may be found. Following genetic traces, one could hope to track the story of steppe nomads, as it were, from rags to riches. But I must admit having been often confronted with a sense of alienation that makes it difficult to assess how to use genetic data. I have the feeling that such evidence is at the same time too much and too little. Relevant studies have been published at an impressive rate in highly respected journals, but the samples from which the ancient DNA information is extracted are minuscule: how relevant are they to population movements across Eurasia over a couple of millennia? Moreover, such data can complicate and often confuse scenarios painstakingly constructed by historians and archaeologists. One might say that may be a good thing: the fresh breath of science can bring a scent of novelty into the stuffy room of historical and archaeological theories. But is that truly so? Only a close analysis can justify that claim, and the risk that this fresh breath may instead be a malicious gust of wind throwing into the air valuable research hypotheses cannot be dismissed in principle.

BENTLEY DREZNER

A lecture on archaeological perspectives on ethnicity in ancient China, delivered by Lothar von Falkenhausen, Professor at the University of California, Los Angeles, was part of the workshop "DNA, History, and Archaeology" organized by Nicola Di Cosmo in October.

There is also a more subtle danger. Studies in genetics are highly standardized. First comes the description of the object of the article and of the samples to be examined, followed by an explanation of the laboratory procedure and a technical exposition of the data. The last section typically comprises a discussion of the results and some concluding remarks summarizing the findings in less technical language. Anyone who does not have the necessary scientific training, like me, would have to focus on the beginning and the end of the essay, and take the rest on faith.

Archaeogeneticists do not shy away from making historical statements and often present complex arguments tying genes and history together. Yet an examination of the historical accounts is no idle or simple exercise. Even in the relatively narrow category of articles directly relevant to my research, the level of attention to historical matters varies substantially. If the "knowledge" that informs the definition and description of historical populations, or events such as conquests and migrations, or even the bare chronology, is superficial or wrong, can the scientific results obtained through DNA tests still be useful? Let's ask this question differently: assuming that all the scientific tests are exactly right, how are we going to use the results if there is no clear understanding of how ancient societies might have functioned in terms of migration, marriage, culturally or politically controlled reproduction, and social stratification?

Stripped down to their scientific essence, the laboratory results are of scarce utility. They require, in order to be useful, a historical and archaeological context, and therefore one could say that testing the adequacy of the historical assumptions and conclusions is just as important as making sure that the tests are done correctly. Let me give a concrete example. Often we read that a particular individual whose DNA is being extracted and tested was a "nomad" or a "Xiongnu" when dealing with samples coming from Iron Age sites in Mongolia, northern China, or Kazakhstan. Yet there is no evidence to associate the individual whose genes we are looking at with an identifiable Xiongnu population or even with "nomads." These categories are highly problematic to begin with, and once the genetic results are classified as such (Xiongnu or nomad) we only add to the difficulty of unraveling an already convoluted and confusing picture.

A recent article (2006) presented the test results of samples of ancient human DNA from the site of Egyin Gol, an Iron Age necropolis in northern Mongolia, conventionally dated by archaeologists between the third century B.C.E. and the fourth or fifth century C.E. The site has been attributed to the Xiongnu culture, and the inhabitants regarded as Xiongnu. The authors surmise that some events must have happened there, since "for many centuries, the Baikal region was a contact zone between Siberian and Central Asian tribes, and significant ethnic events occurred (e.g., wars, territorial conquests, and population movements)." They also state: "the formation and development of the Mongolian population was thus a complex process affected by the mixture of ethnically different people," and finally conclude, "given that the cultural differences which occurred since the fourth century B.C. were important, especially from the Xiongnu empire (third century B.C.–second century A.D.) to the Mongolian one (twelfth century A.D.), it is likely that the impact of the succession of Turkic and Mongolian confederations on the territory of the current Mongolia was a cultural or linguistic process rather than a migratory or genetic one." One is at a loss to make sense of these conclusions, which essentially restate what historians have taken for granted for a very long time. What the genetic tests tell us, as described by the researchers, is that (1) the people whose DNA was extracted were quite close to the present-day population of Mongolia, and (2) the maternal lineages have a different pattern of distribution with respect to paternal ones. To go from these two pieces of information, in themselves quite valuable, to the historical conclusions stated in the article requires a leap that is both unnecessary and unfounded. If we use a known (or presumed known) historical picture to explain a given result, how does genetics contribute to modify and increase historical knowledge? New results should be used first and foremost to generate new research hypotheses.

The tendency to explain the distribution of genes according to assumed patterns of behavior of certain peoples and societies is quite common in ancient DNA studies. Ultimately, these assumptions go back to historical, anthropological, and archaeological models, and sometimes not the best of them. Inevitably one runs the risk of ending up with conclusions that not only accept as given the existing historical narratives, but may confirm particularly poor versions of them. Going back to the Xiongnu, I am surprised that they are taken often as an ancient population in their own right, or, in the best of cases, that variations in the genetic composition of people assumed to be Xiongnu are attributed to the existence of multiple sets of populations within a large empire, to the effects of Xiongnu conquests and subsequent mixing with a great variety of people, or even to what some have defined as "racial toleration" within their empire. In reality, in every case I have seen, the evidence that shows for certain that the people examined were "Xiongnu" (whatever that may mean) or belonged to any empire is next to nil. To attribute genetic admixture to readymade historical

(Continued on page 13)

Nicola Di Cosmo has been the Luce Foundation Professor in East Asian Studies in the School of Historical Studies since 2003. His main field of research is the history of the relations between China and Inner Asia from prehistory to the modern period. He is also interested in the military history of China and Inner Asia, especially in relation to technological and cultural aspects. Last fall, he organized a workshop at the Institute, "DNA, History, and Archaeology," made possible with support from the Fritz Thyssen Stiftung, where archaeologists, archaeobiologists, and historians discussed issues related to questions of biological and cultural classification.

DNA, HISTORY, AND ARCHAEOLOGY

(Continued from page 12)

notions of political expansion and conquest means also that scenarios built as hypotheses by historians and archaeologists are never going to be questioned.

My concern with the way in which geneticists access and deploy historical arguments leads me to another consideration. That DNA evidence can provide clues to unrecorded historical events is surely one of the key potential uses of ancient DNA, but how can we make sure that such a clue is historically meaningful? If ancient DNA can lead to the discovery or even the solution of unknown human events—migration, war, settlement, enslavement, conquest, etc.—it is necessary to make sure that genetic data is interpreted according to scenarios that make sense historically and archaeologically, and often this requires first of all a greater sensitivity toward what we may call the "identity" of an excavated site. Secondly, a certain acquaintance with how ancient populations may have been structured socially, ethnically, and politically is required. It makes a difference if what we regard as an intrusive genetic element appears in a common tomb or in an elaborate elite burial. In other words, the categories used by historians, archaeologists, and anthropologists when they examine ancient remains can be complicated and may not be easily transferred to a biological context.

I believe that historians, especially those working in areas for which written records are nonexistent, ought to be taking seriously the evidence churned out by genetic laboratories. On the other hand, geneticists must realize that the effectiveness of their research is limited unless they access reliable historical information and understand how a historical argument may or may not explain the genetic data. What historians bring to the table depends on how "testable" their historical hypotheses are. To give an example again based on our Xiongnu problem, if DNA research could help form a picture of the genetic distribution in various regions that are regarded as the homeland of early nomads—northern China, Mongolia, Tuva, Transbaikalia, etc.—this would be in itself a great advance, but since this is, in practice, impossible, one might seek to identify those sites that are most promising. Based on what I have been able to cobble together from existing studies, it would be interesting to see whether patterns of genetic distribution may correlate with advanced technology (for instance metallurgy), with centers of political power, and with early trade routes. Such a rough and unsophisticated hypothesis may be a starting point for a cooperative project between historians, archaeologists, and geneticists. Any result in that direction would take us one step forward in our understanding of large cultural and demographic events in central, northern, and east Asia, and of the fateful genesis of ancient nomadic empires. ■

Paul Hodgson: The Art of Doubt

CLIFF MOORE

Artist Paul Hodgson spent some time at the Institute as a Director's Visitor last fall. He created the work he is pictured with above (shown here in progress) in a studio on campus and gave the talk "Honest Doubt" to the Friends of the Institute for Advanced Study (see article, below, and video at http://video.ias.edu/hodgson-honest-doubt), excerpts of which follow.

I started to use doubt as a subject in my work while I was an undergraduate student in the Fine Art Department at the University of Newcastle upon Tyne.

In works from this time, the elements that I chose were presented through the use of collage, monotype and screenprint, through the pouring of paint, and the smearing of paint, but rarely through the use of a "signature" mark with the aid of a brush; they are second and third hand, layered and fragmented.

The various ways in which I have recorded elements on the surface of the canvas are joined together by one common factor: distrust in laying down a direct mark.

Why choose one set of elements instead of another, and one narrative order out of many?

In some works, I intend doubtfulness to permeate both the pose of the figure portrayed, the thinness of the gestural area of paint behind him, and the fact that, unable to settle upon a single "style," I move from painterly gesture—a thin scrapping of paint—to photographic material, to thick encrusted pigment.

In other works, I want to suggest the moment before a decision is made; a decision that might serve to separate two forms, two ideas—perhaps rendering one dark and one light.

The work that I have been developing over the last few years could be described as a form of "meta-painting," or "meta-image" making; work that attempts to communicate content by revealing its own artifice; content that is, in itself, attempting to express doubtfulness over certain assumed ideas that help propagate this artifice in the first place. ■

In Honor of Hans Kohn

In November, School of Historical Studies Faculty and Members joined Immanuel Kohn, a Trustee Emeritus of the Institute, and his wife Vera Kohn to dedicate a new room for seminars and gatherings in Fuld Hall. The room, which was made possible by the Kohns' support, is named in honor of Immanuel Kohn's father Hans Kohn, a distinguished historian of nationalism and a Member in the School of Historical Studies in 1948 and 1955.

KATE ABLUTZ

ANDREA KANE

Peter Goddard, Director of the Institute, addressing the Friends in May 2010

Become a Friend of the Institute

Friends of the Institute for Advanced Study, a dedicated group of more than two hundred donors who provide the Institute with its most significant source of unrestricted financial support, is always interested in welcoming new members. As committed partners in the advancement of research and scholarship, Friends are an integral part of the Institute community and are encouraged to participate in the Institute's intellectual and cultural life, including attending talks and lectures by Faculty, Members, and invited speakers.

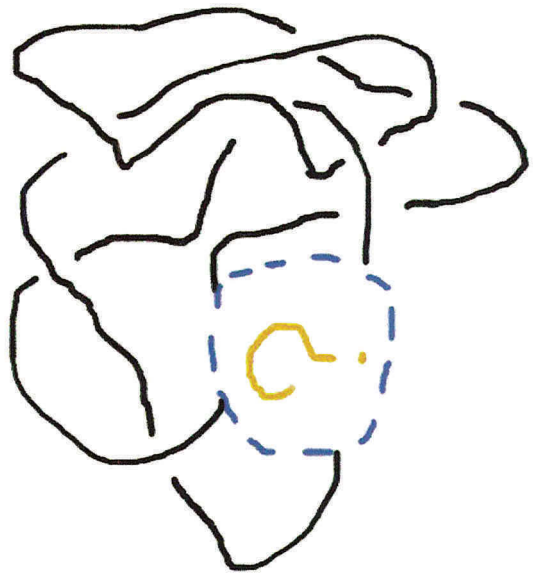
In addition to Edward Witten, Charles Simonyi Professor in the School of Natural Sciences (see article, page 1), and Paul Hodgson (see article, above), recent Friends talks have been presented by William Grimes of the *New York Times* and Harold Shapiro, President Emeritus and Professor of Economics and Public Affairs at Princeton University and an Institute Trustee. Upcoming speakers include Tarik O'Regan, a composer and Director's Visitor, and Marilena LoVerde, the Friends of the Institute for Advanced Study Member in the School of Natural Sciences.

Beyond a full schedule of lectures and talks, every year Friends are guests of Peter and Helen Goddard at two special events held at the Director's home—a holiday gathering with Institute Faculty and a picnic each May. Friends Open Table, introduced this year and already popular, encourages new and existing Friends to gather for dinner every month in the Institute's Dining Hall at a table hosted by a member of the Friends Executive Committee. Additionally, Friends are invited to attend the Edward T. Cone Concert Series, for which they receive priority ticketing; the Institute Film Series; and other special lectures and events.

For more information about joining the Friends, please contact Pamela Hughes by phone, (609) 734-8204, or email, phughes@ias.edu, or visit the Friends website, www.ias.edu/people/friends. ■

IAS The Institute Letter

Spring 2011



In the twentieth century, mathematicians developed a deep theory of knots, which was revolutionized by the discovery of the Jones polynomial—a way to calculate a number for every knot—by Vaughan F. R. Jones in the early 1980s. In the following pages, Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, describes the history and development of the Jones polynomial and his interest in knot theory as a physicist (see article, page 1).

Witten explains how the method developed by Jones and other mathematicians for comparing knots that differ by how a missing piece is filled in (as depicted by the question mark in the image above) has led to many links between the Jones polynomial and mathematical physics.

In quantum physics, a knot may be regarded as the orbit in spacetime of a charged particle. One way of calculating the Jones polynomial in quantum theory involves using the Chern-Simons function for gauge fields. But to use the Chern-Simons function, the knot must be a path in a spacetime of three dimensions (two space dimensions and one time dimension) rather than the four dimensions (three space dimensions and one dimension of time) of the real world. Beginning in the 1980s, efforts by Members in the School of Mathematics—primary among them Igor Frenkel, Louis Crane, and Michael Khovanov—have generalized the Jones polynomial to introduce a concept known as Khovanov homology, which allows the knot to become a physical object in four spacetime dimensions.

During the last decade, Sergei Gukov, Albert Schwarz, and Cumrun Vafa, former Members in the Schools of Mathematics and Natural Sciences, have developed a quantum interpretation of Khovanov homology. Witten spent the last year constructing his own approach, which involves Chern-Simons gauge theory and electric-magnetic duality and relates Khovanov homology to theories in four, five, and six dimensions. These quantum interpretations closely connect Khovanov homology to cutting-edge ideas about quantum field theory and string theory.

IAS The Institute Letter

Spring 2011

Institute for
Advanced Study
Einstein Drive
Princeton, New Jersey 08540
(609) 734-8000
www.ias.edu