IAS
The Institute Letter

Institute for Advanced Study

Spring 2012

Dipesh Chakrabarty Appointed Professor in School of Social Science

ROCHONA MAJUMDAR

Dipesh Chakrabarty

Dipesh Chakrabarty, a social historian whose research has transformed understanding of nationalist and postcolonial historiographies, particularly in the context of modern South Asia, has been appointed to the Faculty of the School of Social Science at the Institute, with effect from July 1, 2013, succeeding Joan Wallach Scott as Harold F. Linder Professor. Scott has served on the Faculty of the School since 1985, and will become Professor Emerita from July 2013.

Chakrabarty is currently Lawrence A. Kimpton Distinguished Service Professor in the Department of History and the Department of South Asian Languages and Civilizations at the University of Chicago. His interdisciplinary analyses of the claims, procedures, and evolution of historical knowledge and its profound involvement with questions of nationalism, colonial rule, modernization, economic and political development, and politics at large have placed him among the leading figures in the field.

"Dipesh Chakrabarty is a historian of extraordinary range and depth whose work has reshaped our understanding of colonial and postcolonial history," said Peter Goddard, Director of the Institute. "His work, characterized by exceptional rigor, originality, and brilliance, has been widely influential. We look forward to his joining our community."

"I am delighted and honored to have the opportunity to contribute to and share in the rich and innovative intellectual life of the Institute," said Chakrabarty. "I look forward to being part of the academic conversations and interactions the IAS makes possible."

Regarded as one of the founders of a new comparative and transnational history,

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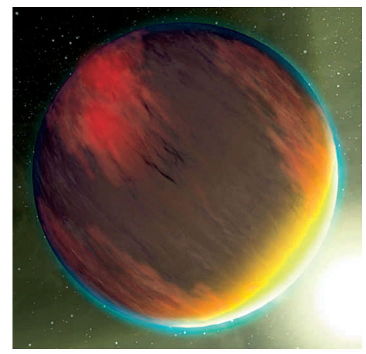
Extrasolar Planets and the New Astronomy

BY ARISTOTLE SOCRATES



PD-USGOV-NASA

Artist's impression of a hot Jupiter, a type of extrasolar planet. Though hot Jupiters are similar in mass and composition to Jupiter, they can be over one hundred times closer to their stellar host, orbiting about it once every few days.

The desire to discover distant, rare, and strange objects dominated twentieth-century astronomy, for which increasingly larger and more sensitive telescopes were constructed.

The act of carrying out this objective has brought enormous—and somewhat unbelievable—rewards: We now accept that we orbit a thermonuclear furnace, the Sun, whose physical properties are quite common, so common that there are nearly 100 billion Sun-like stars within our galaxy, the Milky Way. It was discovered that the Milky Way was not, in fact, the entire Universe; the observable Universe is of order many billions of light years across (that's big), and there are of order 100 billion galaxies like our own floating around within it. In the center of these galaxies there happen to be super-massive black holes whose masses can be up to 10 billion times the mass of the Sun. When these enormous black holes are built up by in-falling gas, they are called "quasars," and produce the equivalent of 100 trillion Suns worth of light within a volume comparable to our solar system. The greater the separation between any two galaxies or quasars, the greater the rate at which they move apart or, in other words, the Universe is expanding. Perhaps even more surprising, the Universe is primarily made up of stuff that we can neither see nor feel, i.e., dark energy and dark matter. The strategy of building bigger and more sensitive telescopes, meanwhile, has produced a growing number of "smaller" results that continue to employ regiments of astronomers: gamma-ray bursts, pulsars, X-ray emitting binary stars,

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'An Artificially Created Universe': The Electronic Computer Project at IAS

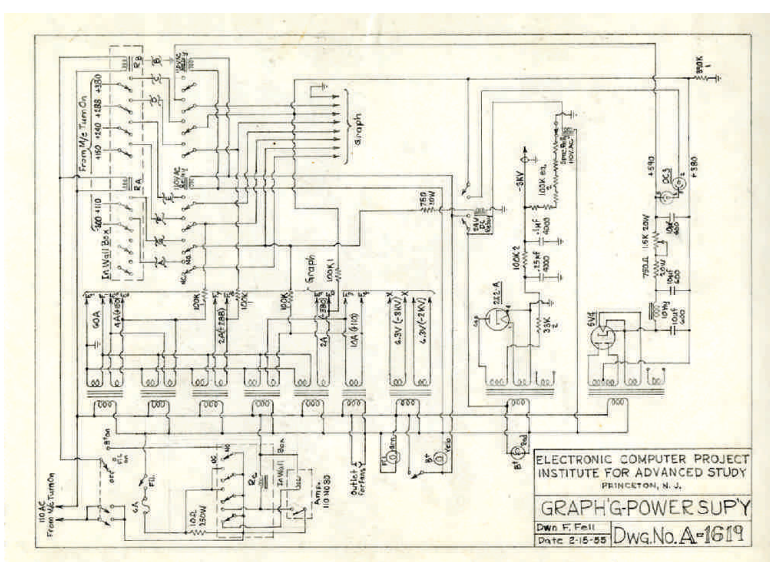
BY GEORGE DYSON

I am thinking about something much more important than bombs. I am thinking about computers.

— John von Neumann, 1946

There are two kinds of creation myths: those where life arises out of the mud, and those where life falls from the sky. In this creation myth, computers arose from the mud, and code fell from the sky.

In late 1945, at the Institute for Advanced Study in Princeton, New Jersey, Hungarian-American mathematician John von Neumann gathered a small group of engineers to begin designing, building, and programming an electronic digital computer, with five kilobytes of storage, whose attention could be switched in 24 microseconds from one memory location to the next. The entire digital universe can be traced directly to this 32-by-32-by-40-bit nucleus: less memory than is allocated to displaying a single icon on a computer screen today.



INSTITUTE FOR ADVANCED STUDY

Diagram of the graphing power supply of the Electronic Computer Project, 1955

Von Neumann's project was the physical realization of Alan Turing's Universal Machine, a theoretical construct invented in 1936. It was not the first computer. It was not even the second or third computer. It was, however, among the first computers to make full use of a high-speed random-access storage matrix, and became the machine whose coding was most widely replicated and whose logical architecture was most widely reproduced. The stored-program computer, as conceived by Alan Turing and delivered by John von Neumann, broke the distinction between numbers that *mean* things and numbers that *do* things. Our universe would never be the same.

Working outside the bounds of industry, breaking the rules of academia, and relying largely on the U.S. government for support, a dozen engineers in their twenties and thirties designed and built von Neumann's computer for less than $1 million in

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News of the Institute Community

DIDIER FASSIN, James D. Wolfensohn Professor in the School of Social Science, has published *La Force de l'Ordre: Une Anthropologie de la Police des Quartiers* (Le Seuil, 2011). The book provides the first ethnography of the police in France and sheds light on contemporary politics of security.

PETER SARNAK, Professor in the School of Mathematics, has been awarded the Mahler Lectureship by the Australian Mathematical Society. He was honored for "major contributions to number theory and to questions in analysis motivated by number theory."

FREEMAN J. DYSON, Professor Emeritus in the School of Natural Sciences, has been elected as a Foreign Member of the Russian Academy of Sciences.

The 2012 Wolf Prize in Mathematics has been awarded to LUIS CAFFARELLI, former Professor (1986–96) and Member (2009) in the School of Mathematics, for his work on partial differential equations, and to MICHAEL ASCHBACHER, former Member (1978–79) in the School of Mathematics, for his work on the theory of finite groups. Caffarelli is Professor of Mathematics at the University of Texas at Austin. Aschbacher is the Shaler Arthur Hanisch Professor of Mathematics at the California Institute of Technology.

The National Academy of Sciences has awarded the 2012 Public Welfare Medal to HAROLD T. SHAPIRO, an Institute Trustee and President Emeritus and Professor of Economics and Public Affairs at Princeton University. Shapiro was honored for his efforts to distill, debate, and resolve complex aspects of controversial scientific issues.

The National Endowment for the Humanities has awarded the National Humanities Medal to AMARTYA SEN, former Institute Trustee (1987–94); ROBERT DARNTON, former Member (1979, 1980, 1981) in the School of Social Science and Visitor (1979–82) in the School of Historical Studies; and TEOFILO F. RUIZ, former Member (1983–84) in the School of Historical Studies. Sen is Thomas W. Lamont University Professor and Professor of Economics and Philosophy at Harvard University. Darnton is Carl H. Pforzheimer University Professor at Harvard and Director of the Harvard University Library. Ruiz is Distinguished Professor of History at the University of California, Los Angeles.

PAUL MORAVEC, former Artist-in-Residence (2007–08) and Artistic Consultant (2008–09), is one of four composers to be awarded the 2012 Arts and Letters Award in Music from the American Academy of Arts and Letters.

The Federalist Society has awarded its Paul M. Bator Award for excellence in legal scholarship, teaching, and public impact, to EUGENE KONTOROVICH, Member in the School of Social Science.

RASHID SUNYAEV, the Maureen and John Hendricks Visiting Professor in the School of Natural Sciences at the Institute, has won the 2012 Benjamin Franklin Medal in Physics. Sunyaev was recognized for his contributions to the understanding of the early universe and the properties of black holes. He is Director of the Max Planck Institute for Astrophysics in Garching, Germany, and Chief Scientist at the Russian Academy of Sciences Space Research Institute.

The Leroy P. Steele Prize for Mathematical Exposition was awarded to former School of Mathematics Members MICHAEL ASCHBACHER (1978–79), Shaler Arthur Hanisch Professor of Mathematics at the California Institute of Technology; RICHARD LYONS (1978, 1985–86, 1991), Professor of Mathematics at Rutgers, the State University of New Jersey; and RONALD SOLOMON (2003), Professor of Mathematics at the Ohio State University. They were honored, along with Stephen Smith, for their paper "The Classification of Finite Simple Groups: Groups of Characteristic 2 Type" in *Mathematical Surveys and Monographs* 172 (2011).

JACOB BEKENSTEIN, former Member (2009–10) in the School of Natural Sciences, has been awarded the 2012 Wolf Prize in Physics for his work on black holes. Bekenstein is Polak Professor of Theoretical Physics in the Racah Institute of Physics at the Hebrew University of Jerusalem.

JENNIFER CHAYES, former Member (1994–95, 1997) in the School of Mathematics, has received the Women of Vision Leadership Award from the Anita Borg Institute. Chayes is Distinguished Scientist and Managing Director at Microsoft Research New England.

JOSEPH WARREN DAUBEN, former Member (1977–78) in the School of Historical Studies, received the American Mathematical Society Albert Leon Whiteman Memorial Prize, which honors exposition and scholarship on the history of mathematics. Dauben is Distinguished Professor of History and the History of Science at Herbert H. Lehman College and a member of the Ph.D. Program in History at the Graduate Center of the City University of New York.

Former School of Mathematics Members DENNIS DETURCK (1989–90) and HERMAN GLUCK (1962, 1990), along with Daniel Pomerleano and David Shea Vela-Vick, have won the 2012 Chauvenet Prize of the Mathematical Association of America for their paper "The Four Vertex Theorem and Its Converse," published in *Notices of the American Mathematical Society* 54 (2007). DeTurck is Dean of the College of Arts and Sciences, Robert A. Fox Leadership Professor, and Professor of Mathematics at the University of Pennsylvania. Gluck is Professor of Mathematics at the University of Pennsylvania.

ROBBERT DIJKGRAAF, a former Member (1991–92) and Visitor (2002) in the School of Natural Sciences who will become Director of the Institute in July, has been awarded the first Comenius Prize of the Comenius Museum in Naarden, Netherlands, for his advocacy of science and its connections with society, education, politics, and the media. Dijkgraaf is currently President of the Royal Netherlands Academy of Arts and Sciences and Distinguished University Professor of Mathematical Physics at the University of Amsterdam.

BJÖRN ENGQUIST, former Member (1991–92) in the School of Mathematics, has received the George David Birkhoff Prize in Applied Mathematics, awarded jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The award recognized Engquist's contribution to a wide range of powerful computational methods. He holds the Computational and Applied Mathematics Chair I at the University of Texas at Austin.

ROMAN HOLOWINSKY, former Member (2006–07, 2009–10) in the School of Mathematics, has been awarded the 2011 SASTRA Ramanujan Prize. The prize citation recognized Holowinsky's work in analytic theory and theory of modular forms, including work done with former School of Mathematics Members Valentin Blomer (2009) and Kannan Soundararajan (1999–2000, 2009), who is a previous recipient of the prize. Holowinsky is Assistant Professor at the Ohio State University.

ULRICH LEHNER, former Member (2009) in the School of Historical Studies, has received the American Catholic Historical Association's John Gilmary Shea Prize for his book *Enlightened Monks: The German Benedictines (1740–1803)* (Oxford University Press, 2011), which he worked on while in residence at the Institute. Lehner is Assistant Professor and Associate Director of Undergraduate Studies at Marquette University.

The American Mathematical Society Award for Distinguished Public Service was awarded to WILLIAM MCCALLUM, a former Member (1995–96) in the School of Mathematics, for his "energetic and effective efforts in promoting improvements to mathematics education." McCallum is University Distinguished Professor and Head of the Mathematics Department at the University of Arizona.

The National Academy of Sciences has awarded the James Craig Watson Medal to JEREMIAH OSTRIKER, former Visitor (2004–05, 2005–06, 2007) in the School of Natural Sciences. The Academy recognized Ostriker for his contributions to the theory of the interstellar and intergalactic medium, cosmological simulations, the theory of dark matter halos around galaxies, and the development of the Sloan Digital Sky Survey. Ostriker is Professor of Astrophysical Sciences at Princeton University.

SCOTT SHEFFIELD, former Member (2006–07) in the School of Mathematics, has been awarded the 2011 Line and Michel Loève International Prize in Probability. Sheffield is Professor of Mathematics at the Massachusetts Institute of Technology.

The Norwegian Academy of Science and Letters has awarded the 2012 Abel Prize to ENDRE SZEMERÉDI, former Member (2007–08, 2009–10) in the School of Mathematics, for his contributions to discrete mathematics, theoretical computer science, additive number theory, and ergodic theory. Szemerédi is State of New Jersey Professor of Computer Science at Rutgers, the State University of New Jersey, and a Research Fellow at the Alfréd Rényi Institute of Mathematics of the Hungarian Academy of Sciences.

The American Mathematical Society has awarded the Leroy P. Steele Prize for Seminal Contribution to Research to WILLIAM P. THURSTON, a former Member (1972–73, 1976, 1984–85) in the School of Mathematics, for his contributions to low-dimensional topology. Thurston is Jacob Gould Schurman Professor of Mathematics at Cornell University.

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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.

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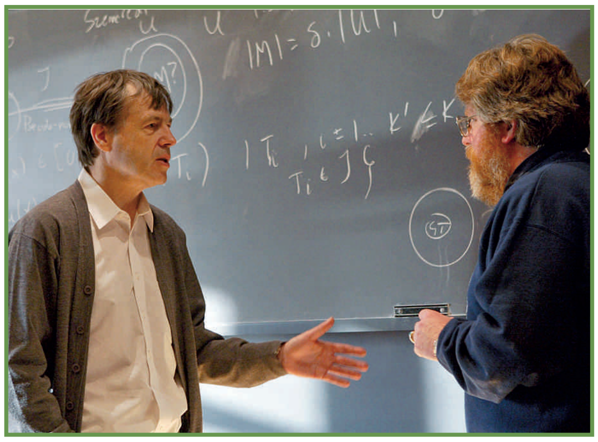
Bourgain Awarded Crafoord Prize in Mathematics



ANDREA KANE

Jean Bourgain (left) with Russell Impagliazzo, Visiting Professor

The Royal Swedish Academy of Sciences announced that it has awarded the 2012 Crafoord Prize in Mathematics to Jean Bourgain, IBM von Neumann Professor in the School of Mathematics at the Institute, and Terence Tao, former Visitor (2005) in the School and current Professor of Mathematics at the University of California, Los Angeles. Bourgain and Tao were cited for their brilliant and groundbreaking work in harmonic analysis, partial differential equations, ergodic theory, number theory, combinatorics, functional analysis, and theoretical computer science.

"Their deep mathematical erudition and exceptional problem-solving ability have enabled them to discover many new and fruitful connections and to make fundamental contributions to current research in several branches of mathematics," the citation reads. "On their own and jointly with others, Jean Bourgain and Terence Tao have made important contributions to many fields of mathematics—from number theory to the theory of nonlinear waves. The majority of their most fundamental results are in the field of mathematical analysis. They have developed and used the toolbox of analysis in groundbreaking and surprising ways. Their ability to change perspective and view problems from new angles has led to many remarkable insights, attracting a great deal of attention among researchers worldwide."

Bourgain, who joined the Faculty of the Institute in 1994, is the winner of the 2010 Shaw Prize in Mathematics. Among his many other honors are the Fields Medal (1994), the Empain Prize (1983), the A. De Leeuw Damry–Bourlart Prize (1985), the Langevin Prize (1985), the Élie Cartan Prize (1990), the Ostrowski Prize (1991), and the Vernadsky Gold Medal (2010). Bourgain is a Foreign Member of the Académie des Sciences in France, the Polish Academy of Sciences, the Royal Swedish Academy of Sciences, and the Academia Europaea.

The Crafoord Prize promotes international basic research in disciplines that complement those for which the Nobel Prizes are awarded. These include astronomy and mathematics, geosciences, and biosciences. There is also an occasional prize awarded in polyarthritis (also known as rheumatoid arthritis, the disease from which the prize's founder suffered) when a special committee recognizes major advances in the field. The Crafoord Prize will be presented in Lund in May, in the presence of Sweden's King Carl XVI Gustaf. ■

BRUCE WHITE

ANDREA KANE

Freeman Dyson, Professor Emeritus in the School of Natural Sciences, Bloomberg Hall

"The Institute"

By Dan Burt

A sign and eight low buildings pass
unnoticed in a field the size of Central
Park: a wall-flower by a college town.
Wandering its halls, one chair offices,
bare egg white walls, nothing stands out until
I reach a lounge where mathematical
notations – integers, fractions, powers,
roots, Greek letters, brackets, slashes – weave
arabesques of genesis and infant stars
for paper napkin audience and nibbled
chocolate bars, on slate where palimpsests
and marginalia in coloured chalks suggest
a coffee break authored this text
a plaque below it warns, *DO NOT ERASE*.

Today's news is no better than yesterday's:
three suicide bombings in the "cradle
of civilisation"; a dowager billionaire
in Voltaire's homeland gives her daughter's
patrimony to a decorator; tar balls seed
hot beaches in a spoiled land whose citizenry
always blame others; immortality remains
elusive and, *sub specie aeternitatis*,
there will be nothing. The same is forecast
for tomorrow, the one bright patch a blackboard
crammed with symbols I cannot understand,
guarded by three words, *DO NOT ERASE*.

From We Look Like This *(Carcanet, 2012) by Dan Burt, former Director's Visitor*

The Campaign for the Institute

The $200 million Campaign for the Institute now underway is aimed at raising new endowment funds to ensure the Institute's financial independence, which enables it to perform its essential role in providing its scholars with the freedom to pursue fundamental research in the sciences and humanities. The $100 million unrestricted challenge grant from the Simons Foundation and the Charles and Lisa Simonyi Fund for Arts and Sciences, announced last summer, serves as the basis for the Campaign, and it must be matched by funds from donors within the next four years. All irrevocable gifts and grants of endowment or annual support will be matched dollar for dollar, and will be counted toward the campaign goal and the Simons and Simonyi challenge (see ELS article, page 12).

Recent gifts toward the Campaign from Institute Trustees are helping to move the Institute closer to its goal. Robert Fernholz, a Trustee of the Institute since 2010, and his wife Luisa have donated funds through the Fernholz Foundation to support a Visiting Professorship in the School of Mathematics. The first Robert and Luisa Fernholz Visiting Professor is Karen Uhlenbeck, Professor and Sid W. Richardson Foundation Regents Chair in Mathematics at the University of Texas at Austin, who is spending the spring term at the Institute. The Fernholzes have provided support to the Institute's School of Mathematics since 2006. Robert Fernholz is Founder and Chairman of the Investment Committee of INTECH Investment Management, and Luisa Fernholz is Professor Emerita of Statistics at Temple University.

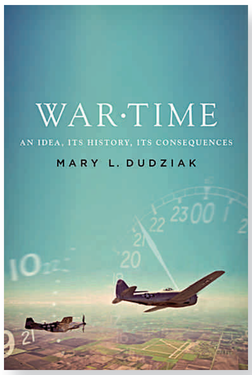
The MacMillan Family Foundation has pledged funds to the Simons Center for Systems Biology in the School of Natural Sciences. Nancy MacMillan, a Trustee of the Institute since 2001, and her husband Duncan MacMillan have also supported work in the Institute's School of Mathematics over the years, including establishing the Herbert H. Maass Professorship in Theoretical Computer Science, a chair currently occupied by Avi Wigderson. The MacMillans have been Friends of the Institute since 1993 and members of the Friends Chairman's Circle since 1997. Nancy MacMillan is the publisher of *Princeton Alumni Weekly*, and Duncan MacMillan is one of the founders of Bloomberg LP.

The Director's Visitors program is of enormous value to the Institute, and John and Maureen Hendricks have agreed to fund the entire program this year and next. Director's Visitors, scholars who work in a variety of fields, including areas not represented in the Schools, contribute much to the vitality of the Institute community. They are invited by the Director for varying periods of time, depending on the nature of their work. Past Director's Visitors have included Subhankar Banerjee, an environmental activist, photographer, and writer; George Dyson, a historian of science and technology and author of *Turing's Cathedral* (see article, page 1); and Tom Phillips, a painter, writer, and composer. Since 2010, John and Maureen Hendricks have supported the appointment of Rashid Sunyaev, the Maureen and John Hendricks Visiting Professor in the School of Natural Sciences and one of the world's most distinguished astrophysicists. John Hendricks, Founder and Chairman of Discovery Communications, has been a Trustee of the Institute since 2010. ■

There are many ways to give to the Institute, including donations of annual support, endowment and program support, and gifts made in conjunction with the estate planning process. For more information or to make a donation, please contact Michael Gehret, Associate Director for Development and Public Affairs, at (609) 734-8218 or mgehret@ias.edu.

The Idea of Wartime

BY MARY L. DUDZIAK



Does war have a time? The idea of "wartime" is regularly invoked by scholars and policymakers, but the temporal element in warfare is rarely directly examined. I came to the Institute in 2007–08 intent on exploring the history of war's impact on American law and politics, but assumptions about wartime were so prevalent in the literature that first I found myself puzzling over ideas about time. Ultimately, this resulted in a book, *War·Time: An Idea, Its History, Its Consequences* (Oxford University Press, 2012).

The idea that time matters to warfare appears in Thomas Hobbes's *Leviathan*: "War consisteth not in battle only, or the act of fighting, but in a tract of time, wherein the will to contend by battle is sufficiently known; and therefore the notion of *time* is to be considered in the nature of war." Time's importance calls for critical inquiry, but time is often treated as if it were a natural phenomenon with an essential nature, shaping human action and thought. Yet our ideas about time are a product of social life, Émile Durkheim and others have argued. Time is of course not produced by clocks, which simply represent an understanding of time. Instead, ideas about time are generated by human beings working in specific historical and cultural contexts. Just as clock time is based on a set of ideas produced not by clocks but by the people who use them, wartime is also a set of ideas derived from social life, not from anything inevitable about war itself.

Yet war seems to structure time, as does the clock. Stephen Kern argues that World War I displaced a multiplicity of "private times," and imposed "homogenous time," through an "imposing coordination of all activity according to a single public time." During World War I, soldiers synchronized their watches before heading into combat. In Eric J. Leed's description of trench warfare, war instead disrupted time's usual order. Battle became an extended present, as considerations of past and future were suspended by the violence of the moment. "The roaring chaos of the barrage effected a kind of hypnotic condition that shattered any rational pattern of cause and effect," so that time had no sequence. And so one meaning of "wartime" is the idea that battle suspends time itself.

War also breaks time into pieces, slicing human experience into eras, creating a before and an after. It often marks the beginning of one historical period, and the end of another. Once historical time is divided, war is thought to occupy a certain kind of time: a wartime. Yet wartime is more than a historical signpost, a passive periodizer. It is thought to function as an abstract historical actor, moving and changing society and creating particular conditions of governance. We think of wartime as *doing things* in history.

Built into the idea of wartime is the assumption that war is temporary. Wartime is thought to be a breach of "normal" time, to be followed by peacetime, so that the beginning of a war is the opening of an era that will, by definition, come to an end. Because of this, the idea of wartime implies a conception of the future. To imagine the future requires an understanding of the past. In wartime thinking, the future is a place beyond war, a time when exceptional measures can be put to rest, and regular life resumed. The future is, in essence, the return to a time that war had suspended.

War also breaks time into pieces, slicing human experience into eras, creating a before and an after. It often marks the beginning of one historical period, and the end of another. Once historical time is divided, war is thought to occupy a certain kind of time: a wartime. Yet wartime is more than a historical signpost, a passive periodizer. It is thought to function as an abstract historical actor, moving and changing society and creating particular conditions of governance. We think of wartime as doing things in history.

The idea that wartime is exceptional can lead to determinism. During the French Revolution, Lynn Hunt suggests in *Measuring Time, Making History*, "a new kind of determinism" appeared. Bertrand Barère, a leading member of the Committee of Public Safety and viewed as a driving force behind the Reign of Terror, "excused his actions as the product of his time." Barère claimed that he did not shape his revolutionary epoch. Instead, he "only did what I had to do, obey it." Barère argued that his time "sovereignly commanded so many peoples and kings, so many geniuses, so many talents, wills, and even events that this submission to the era and this obedience to the spirit of the century cannot be imputed to crime or fault." In American wartime thinking, there is also a powerful sense of determinism. Actions that would normally transgress a rule of law are seen as compelled by the era, as if commanded by time. And, as did Barère, individuals defend themselves by arguing that their actions were compelled or justified by the times.

But is war really bound in time? Particular conflicts have endings, but when we look at the full timeline of American military conflicts, including the "small wars" and the so-called forgotten wars, there are not many years of peacetime. War seems not to be an exception to normal peacetime, but instead more of an enduring condition.

In spite of its persistence, wartime often serves as a justification for a rule of law that bends in favor of the security of the state. This distortion is tolerated because wartime is thought to be a temporary rupture of the usual state of affairs. The assumption of war's temporariness becomes an argument for exceptional policies. And those who cross the line during war sometimes argue that circumstances deprive them of agency; their acts are driven or determined by time.

September 11, 2001, is thought to have opened a new war era. That day countless people in the United States and around the world were thrown together in time as they watched the effects of the terrorist attacks unfold in "real time" on television. It was a moment of "simultaneity," in Benedict Anderson's terms, as the shared experience of horror generated feelings of solidarity among Americans who felt that they and their nation were under attack. Fault lines would soon appear, but a common element lingered on. Many felt that the terrorist attacks had shattered time, and ushered in a new era of history.

This new wartime resulted in broad U.S. government power. The United States went to war in two nations, but the war era was framed in a way that escaped the usual boundaries in space and time. For President George W. Bush, it was a "war on terror," and for President Barack Obama, a "war on Al-Qaeda." Even in Obama's more focused formulation, this was a war that could last as long as the existence of Al-Qaeda affiliates intent on harming Americans in the world, depriving this wartime of its temporal boundaries.

Mary L. Dudziak, the Ginny and Robert Loughlin Member (2007–08) in the School of Social Science, is the Judge Edward J. and Ruey L. Guirado Professor of Law, History, and Political Science at the University of Southern California Law School. She has written extensively about the impact of foreign affairs on civil rights policy during the Cold War and other topics in twentieth-century American legal history.

Enemy combatants can lawfully be detained at Guantánamo and elsewhere "for the duration of hostilities." Wartime detention authority is premised on the idea that it is proper to hold the enemy so that soldiers won't return to battle. But can they be detained for the duration of hostilities that are possibly neverending? The Supreme Court was troubled by this question when it took up post-9/11 cases related to Guantánamo detainees. The Court's initial response was to see the war era as fitting within the traditional paradigm, assuming that wartime was temporary. But the ongoing character of the war on terror challenged this idea. The present conflict, "if measured from September 11, 2001, to the present, is already among the longest wars in American history," Justice Anthony Kennedy wrote in *Boumediene v. Bush* (2008). Judicial oversight through habeas corpus was needed since "the consequence of error may be detention of persons for the duration of hostilities that may last a generation or more." The lack of time boundaries made this conflict different than past wars, he reasoned, and this justified the Court's placing modest limits on executive power even during a time conceptualized as a wartime.

The Court's attempt to grapple with the concept of wartime in the detainee cases reveals a more enduring problem. If wartime lacks time boundaries, then wartime is normal time, rather than exceptional time. This means that the law during war must be seen as the form of law we usually practice rather than a suspension of an idealized understanding of law. ■

FROM THE IAS WEBSITE:

Maude Barlow on the Global Water Crisis

CHRISTINE FERRARA

"We are a planet now running out of fresh water sources. The water is somewhere on the planet, but we're either polluting it or diverting it or moving it from where we can access it to where we cannot at an absolutely astounding rate using modern technology that we didn't have fifty years ago," says Maude Barlow, Chair of the Council of Canadians and of Food and Water Watch, who presented "The Global Water Crisis and the Coming Battle for the Right to Water" at the Institute last fall.

"A very important concept that you're going to hear more about in the next few years is called virtual water, and that virtual water is the water that is used to produce or grow something, usually commodities. If you export that commodity out of your watershed or out of your country, you're actually exporting the water. You don't think of it as export of water. We think about export of water as being a pipeline that you put into a lake or whatever. . . . Americans are amazed when I tell them that you use—and you have a crisis of water in parts of this country, a very serious one—fully one-third of all your domestic water consumption every day to grow crops that are then exported out of the country. So fully a third of your domestic water use every single day leaves your country, and it's mostly from states that don't have the water to be able to afford that in the first place. So it's a very serious issue and one that you're going to hear a lot more about in the coming years."

Barlow's talk was part of the Institute's annual series, Lectures on Public Policy, which aims to address issues relevant to contemporary politics, social conditions, and scientific matters of broad import. A video of Barlow's lecture is available at http://video.ias.edu/barlow-public-policy.

Unpacking the Bachelor Pad

BY JESSICA ELLEN SEWELL

The mid-1950s saw the invention of a new, highly mythologized housing type, the bachelor pad, articulated most fully in the pages of *Playboy* and in films. The bachelor pad is an apartment for a single professional man, organized for entertaining and pleasure, and displaying tasteful consumption. The bachelor pad was culturally salient at this particular historical moment because it linked a culture increasingly focused on consumption and what sociologists and cultural commentators in the late 1950s argued was a "crisis in masculinity." The bachelor pad provided a compelling fantasy of individual consumption and economic and sexual power to counter that crisis, but at the same time, helped to produce the masculinity crisis by problematizing straight male domesticity.

As described in *Playboy*, the pad "is, or should be, the outward reflection of his [the bachelor's] inner self—a comfortable, livable, and yet exciting expression of the person he is and the life he leads."[1] It is precisely this inner self that was seen to be in crisis in the late 1950s: men's sense of themselves as individuals had been stripped away, a state that was blamed partly on the conformity of corporate America and partly on women. Not only did women push men to work in order to satisfy women's consumerist desires, but their control over men was also understood as spatial—as Philip Wylie argued in *Playboy*, women had taken over bars, clubs, and workplaces, and "wanted to invade everything masculine, emasculate it, cover it with dimity, occupy it forever."[2] The house similarly had become "a boudoir-kitchen-nursery, dreamed up by women, for women, and as if males did not exist as males."[3]

The bachelor pad served as a way to think of an alternative masculinity, apart from work and family. In a 1958 essay in *Esquire* on "The Crisis of American Masculinity," Arthur Schlesinger Jr. argued that men needed to "recover a sense of individual spontaneity. And to do this, a man must visualize himself as an individual apart from the group, whatever it is, which defines his values and commands his loyalty."[4] Visualizing themselves as bachelors, living lives of leisure, may have provided just such an opportunity for already-married men to recover their individuality, as well as to base that individuality on consumption. At the time these bachelor pads were articulated, bachelors were rare: in 1956, men's median age at first marriage was at an all-time low of 22.5.[5] Although potentially a model for actual single men, the bachelor pad functioned primarily as a site to imagine a more fulfilling masculine domesticity and to conceptualize a masculine identity based on the consumption of goods rather than work or family.

Architecturally, *Playboy*'s bachelor pads are dream doubles of the suburban home. The classic *Playboy* bachelor pads are penthouses, so rather than being constrained by occupying just one portion of the floor space of an apartment building, they sit on top of the building, much like a suburban ranch house placed atop a tower. Space in them is open and flowing, following a central tenet of architectural modernism dating back to the 1920s. In addition, their integration of indoors and outdoors through sliding doors and continuous flooring reflected the 1950s–60s Californian trend in suburban house design. Similarly, the *Playboy* bachelor pads' interiors are examples of the high style modernism championed by *Architectural Record* and modern architects. Each *Playboy* pad includes several pieces designed by prominent modernist designers, including Eero Saarinen, Charles and Ray Eames, and Isamu Noguchi. Signature furnishings take center stage in the designs, often dominating the rooms, and are referred to repeatedly in the text. They are also pulled out and shown separately, and information about the designer, manufacturer, and price is included in captions. For readers, the *Playboy* bachelor pad designs could function as both aspirational fantasies and catalogues.

1 "Playboy's Penthouse Apartment," *Playboy*, October 1956, 65

2 Philip Wylie, "The Womanization of America," *Playboy*, October 1958, 77

3 Wylie, Womanization, 77

4 Arthur Schlesinger Jr., "The Crisis of American Masculinity," *Esquire*, November 1958, 65

5 U.S. Census Bureau, "Table MS-2. Estimated Median Age at First Marriage, by Sex: 1890 to Present," in "Families and Living Arrangements," http://www.census.gov/population/www/socdemo/hh-fam.html

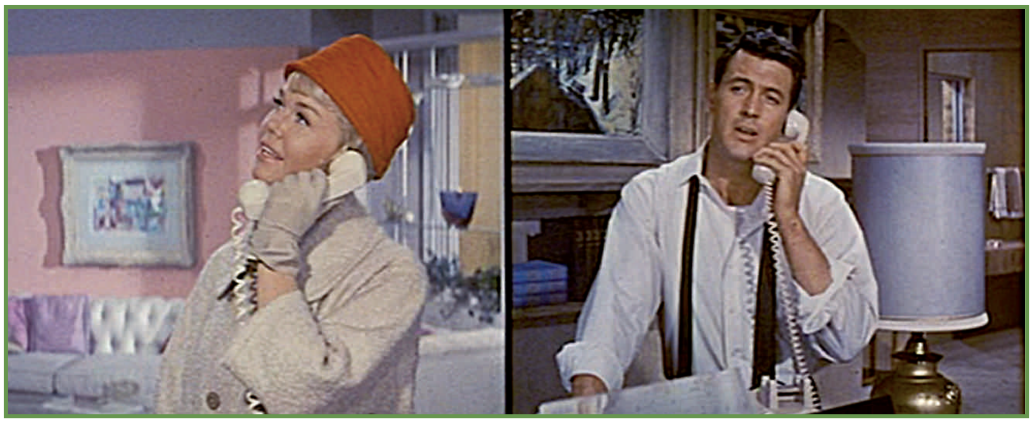


Image from Pillow Talk (1959). Split screen heightens the contrast between the feminine apartment of Jan Morrow (Doris Day) and Brad Allen (Rock Hudson)'s bachelor pad.

The bachelor pad's interior needed to be stylish, because style is essential to the persona of the *Playboy* bachelor and his upwardly mobile aspirations. However, any interest in interior design was very clearly gendered, then as now, and was associated both with women and with gay men. Thus the design needed to be clearly masculine. Traditional modes of masculine design, however, modeled on the men's club and the hunting lodge, were too completely homosocial, and inappropriate for a straight man who should want to entertain and seduce women in his home. Without these models to resort to, the design cues of heterosexual masculinity were subtle. While the dead animals and club chairs of these older homosocial spaces have no place here, their traces remain in the evocation of hunting through art such as the Lascaux motifs in the bathroom of a 1956 penthouse apartment featured in *Playboy* as well as in the use of leather, dark colors, and rich textures. Textures also expressed the ruggedness and roughness of masculinity, and set it apart from the femininity that had been historically linked with smoothness. We can see these masculine signs playing out in the 1959 film *Pillow Talk*, which juxtaposes the bachelor pad of Brad Allen (Rock Hudson) and the feminine apartment of Jan Morrow (Doris Day). The walls of Jan's apartment are smoothly painted in light colors, and the overall color scheme is pastel, accented with images of flowers and gardens. In contrast, Brad's apartment is relatively dark, with modern oil paintings and landscapes in dark wood frames, and dark wood and leather furnishings. One wall is of bare brick, and most of the others are covered in textured bark-like wallpaper. Straight masculinity is also performed through quite modernist absences; in *Playboy*'s 1956 penthouse apartment, "lamps, which would impede the clean, open look of the place, are virtually dispensed with; there is a complete absence of bric-a-brac, patterned fabrics, pleats and ruffles."[6]

The bachelor pad provided a compelling fantasy of individual consumption and economic and sexual power to counter that crisis, but at the same time, helped to produce the masculinity crisis by problematizing straight male domesticity.

Liquor and technology also help to masculinize the pad. Each pad has not just one, but several bars, which permit "the canny bachelor to remain in the room while mixing a cool one for his intended quarry. No chance of … leaving her cozily curled up on the couch with her shoes off and returning to find her mind changed, purse in hand, and the young lady ready to go home, damn it."[7] Liquor serves as a marker of masculinity, but more importantly the bar is the center of entertainment, by means of which guests are both served drinks and entertained by the bachelor's skill as a bartender. Technology similarly helps to entertain guests. Elaborate entertainment systems combining stereo and TV with the latest in entertainment gadgetry not only allows a bachelor to play music for his guests, but also become conversation pieces in themselves. Similarly, kitchen gadgets help him entertain guests with his "electronic showmanship" as he demonstrates his conveyor-belt cabinets, induction range, and "automatic electric cooking utensils."[8] Technology heightens the masculinity of the bachelor pad in several ways: it brings with it the associations of science and technology, it is a tool for displaying connoisseurship of both gadgets and music, and it functions as the means to total mastery of the environment. This mastery is expressed in the ubiquitous control units, which allow the bachelor to control nearly every aspect of the environment of the bachelor pad, including lights, doors, curtains, music, telephone answering machine, and even the automatic frying of eggs and bacon. Control panels express a fantasy of pure leisure, in which the bachelor can spend his entire life indolently in bed taking care of every need by remote control, as well as a fantasy of total control, in which the bachelor is able to control everything around him by the push of a button, even, perhaps, his playmate. Control panels serve not only as a means of performing mastery, but also of orchestrating the tools of seduction, including mood music, lights, and door locks. The entire apartment serves as a machine of seduction, which the bachelor controls in order to attract, inebriate, and eventually trap his female prey. This motif of seduction serves to heterosexualize the bachelor pad and its pleasures, helping to diffuse the queer implications of the bachelor's interest in design and disinterest in marriage.

The bachelor pad is centered on individual pleasure and stylish consumption, framed in the context of the sexual conquest of women, but with much more complex meanings and potential uses. It enables a kind of fantasmatic escape from suburbia, serving as an architectural dream double of the suburban house. It is a site for men to imagine what a masculine interior that expressed their own personality might be, and a way to learn how to use consumption to construct a new model of manhood for themselves, one made necessary by the masculinity crisis that the pad also helped to construct. ■

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6 "Playboy's Penthouse Apartment," *Playboy*, October 1956, 70

7 "Playboy's Penthouse Apartment," *Playboy*, September 1956, 59

8 "Duplex Penthouse," *Playboy*, January 1970, 233; "Kitchenless Kitchen," *Playboy*, October 1959, 54–55

Embedded Portraits: Appending a New Myth to an Old Myth

BY CHRISTOPHER S. WOOD

Religious art of the late Middle Ages and Renaissance in Europe was marked by the creeping presence of the prosaic, the concrete, the familiar, the everyday. Vivid descriptions of furniture and clothes, local flora and landscapes, hometown buildings and skylines, vignettes of laboring and sporting peasants threatened to distract the devout beholder from the sacred narrative. The purpose of the painting, after all, was to train the mind on the episodes of the lives of Christ, the Virgin Mary, and the saints. A dramatic instance of this profanation of the cult image was the embedded portrait, the topic of my research at the IAS in fall 2011.

The embedded portrait is the image of a real, modern person, usually the donor or person who paid for the painting, introduced into the narrative. The donor has him- or herself depicted in an attitude of pious attentiveness. A good example is the *Nativity of Christ* by the Flemish artist Rogier van der Weyden, painted in the middle years of the fifteenth century—the exact date is unknown—and today in the Gemäldegalerie in Berlin. This is the central section of a three-paneled altarpiece, or triptych, perhaps once mounted on an altar in a chapel, perhaps displayed in an altar-like space in a home. Mary and Joseph, sharing quarters with an ox and an ass, contemplate the naked body of the Child. The stall is pictured as an ancient building in ruins, a symbol of the Jewish and pagan belief systems that Christianity was meant to supersede. The city in the background resembles neither Bethlehem nor Jerusalem but rather, with its spires, gables, and tiled roofs, a modern northern European town. The gentleman at the right, finally, wears an expensive-looking fur-lined coat and wooden clogs to protect his fine pointed shoes. He presses his hands together in reverence. This is the donor. He is not identified by an inscription or a coat of arms. But there is good reason to believe, on the basis of the painting's whereabouts in the seventeenth century, that he is Pieter Bladelin, a man of respectable origins who rose through political acumen to a high station in the court of the Duke of Burgundy, Philip the Good, in Bruges.

The portrait with its hidden reserve of life reveals the characters surrounding it to be mere characters. The real subject of Rogier van der Weyden's painting is the tension between emergent time and mythic time.

Bladelin is not a diminutive supplement to the sacred painting, pressed into a margin or a corner. He appears in full scale alongside the holy personages. He is not disguised as a historical figure; as one of the Three Magi, for example. The disguised portrait, or cryptoportrait, was a favored tactic of some of Bladelin's contemporaries. Bladelin is not playing a role; he appears as himself, in his own clothes. He occupies a measurable patch of ground at the site of the Nativity—"real estate" in Bethlehem, as it were. His body casts a shadow. And yet the Virgin and Joseph take no notice of him. Surely we are not meant to believe that if they turned their heads they would see him kneeling there. He is an anachronistic interloper, an invader from another time and space.

Not much is known about Bladelin the man. His patron Philip the Good valued his political judgment and rewarded him with financial responsibility, eventually with the lucrative post of treasurer and governor general of Burgundian state finance. A contemporary chronicler described him as *riche de biens de fortune outre mesure*, "wealthy beyond measure." Van der Weyden's painting is the only image of Bladelin that survives, and it shows a humble Christian immersed in grave reflection on the mystery of the Incarnation and the promise of Redemption. The embedded portrait is a public, or semipublic (we don't know who had access to the picture), profession of his piety. Did Bladelin believe that the Virgin Mary herself, jealous of her cult, was keeping watch over the shrine and was also impressed by this painted proof of his devotion? It is hard to say.

Nativity of Christ *by the Flemish artist Rogier van der Weyden, painted in the middle years of the fifteenth century, plants a portrait of the artist's donor Pieter Bladelin at the site of the Nativity. The embedded portrait casts doubt on the factuality of the persons and events described by the rest of the picture and introduces the modern myth of human subjectivity and self-awareness.*

The painter van der Weyden, subtlest of artists, in his own lifetime the most admired artist in Europe, was no mere servant of the donor Bladelin. He introduces ambiguity into the image by suggesting that the modern man's participation in the historical event is incomplete, imperfect. Bladelin's gaze, hands, and knees do not point directly at the Child but rather just to his left. This indirection raises the possibility that the painting represents not the Nativity itself but the donor's vivid imaginative recreation of the event. Yet the slight overlap of Bladelin's body and the spreading robes of the Virgin, once we have noticed it, suggests just the opposite, namely, that he is really there. Perhaps it is best to think of the painting not as a stable statement of fact but as a carefully calibrated reflection on the difficulty of communicating with personages doubly remote from our here and now: distant in time, but also distant by virtue of their enviable continuity with the divine source of authority and meaning.

The painting emphasizes Bladelin's incomplete participation in the scene. The portrait is set like a gem in the midst of the painting. The dense description of the bowed head is radiant. Bladelin's physiognomy is more memorable than the generic heads of Mary and Joseph. The artificial worlds that the religious imagination builds are unlike the world experienced every day as fact. The painting acknowledges that dissimilarity by staging a clash between two different modes of pictorial signification. On the one hand, there is the Holy Family, the birth-stall, the ox and the ass, and the angels. The picture summons these elements of the myth by quoting other pictures. The painter's own picture cannot stray too far from established pictorial conventions or its subject will not be recognizable. The beholder must believe that the pictorial tradition supporting this painting is rooted in antiquity and transmits reliable knowledge about the historical Nativity. On the other hand, there is the portrait of Bladelin. That portrait does nothing other than point to something real in the world. Rogier van der Weyden has passively transcribed a patch of reality. Bladelin's person is a singular fact that almost surely had never before been depicted. The significance of that fact—Bladelin's unique appearance—is not clear. Why did a sacred image need to record that appearance? The depictions of the Holy Family, derived from tradition, carry with them bundles of associations and meaning. Bladelin's portrait does nothing other than anchor the painting, and the altar and chapel it adorns, to Bladelin the man.

But the portrait has another significance that emerges only when the way it is linked to the factual world is compared to the way the rest of the picture is linked to reality. The portrait's strong referential link to the world is achieved by the painter's dazzling technical skill. The portrait convinces us of its own fidelity to its model even though we don't have the model to compare it to. Before the fifteenth century in Europe, painting did not have this weapon in its arsenal. Now suddenly the portrait makes the factual world reappear inside paintings. The embedded portrait casts doubt on the factuality of the persons and events described by the rest of the picture. The portrait lands inside the religious painting, the depicted myth, as a foreign body. It is a hard fragment of the real that suggests that everything around it is a mere fiction, a product of a weaker form of signification.

By introducing irreducible fragments of real life, in the form of portraits and other individuated descriptions like the cityscape in the background, the painted image opened its borders to lived experience. For experience, the world is emergent. It is always unfolding in time. Painting has difficulty representing this kind of time. The portrait tries to do that, paradoxically, by representing the individual fixed in historical time. For that individual, and we know this from our own experience, is exposed in every way to the passage of time. The portrait with its hidden reserve of life reveals the characters surrounding it to be mere characters. The real subject of Rogier van der Weyden's painting is the tension between emergent time and mythic time.

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So there are two ways of looking at the painting. We can almost see the painting "flip" as we look at it first one way, then the other. One might choose to see the portrait of Bladelin as a blank, unwelcome dead spot in the scene that contributes nothing to our confidence in the historical reality of the Nativity, and nothing to our understanding of the meaning of the event. From that point of view, the portrait has only a minimal capacity to generate meaning. It is not really a symbol of anything, it just is. It is sub-artistic, in the same way that photography is in some sense sub-artistic. Or one might choose to see the portrait as the living core of the painting, animating a dead Biblical story by throwing it open to human experience and subjectivity. There are two dark apertures in the ground in front of Bladelin, one of them covered by a grill, opening onto a subterranean cavity. That cellar is the prison-house of the satanic energies that Christ will one day subdue through his sacrifice. Is it not also the painting's metaphor for the recesses of the self—for the unconscious, we would say today—where the conflicts of the mind with itself must be contained for the sake of social life? The image of the donor appends a new myth to the old myth: the powerful modern myth of human subjectivity, with its depths of feeling and self-awareness, as the ultimate source of meaning. The modern devout is no longer the presumptuous intruder at someone else's event. Now it starts to seem possible that the sacred event is nothing other than the creature of his imagination. ■

The History of Historical Practice and the Study of the Middle Ages

BY PAUL ANTONY HAYWARD

A natural starting point for any attempt to know a past society is its histories—the texts with which its members recorded what had happened and was happening in their world. Many precious witnesses of this kind have survived from medieval Europe, but they are not easily used to answer the questions that modern historians would like to ask.

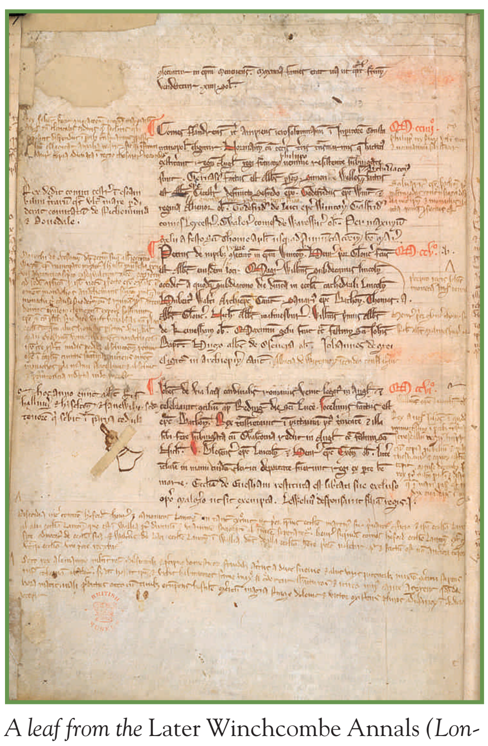
In essence, three types of historical writing flourished in the Middle Ages: chronicles, hagiography, and the rhetorical monograph. The first category refers to seemingly simple lists of events or, to use the current jargon, "factoids." These texts usually arrange their factoids in some sort of chronological order; many assign them to the *anni*, or years, in which they took place, for which reason they are often called "annals." The second type comprises records of things that God has done in this world, through the grace that he has bestowed on his saints and their devotees. The third category refers to narratives that celebrate or criticize the acts of rulers, dynasties, or communities.

All three types clash with modern ways of thinking. Hagiographical texts baffle, because they are the most overtly empiricist and yet, it often seems, the most unreliable. They ask us to believe that God was an active presence in the life of a certain saint and his or her people, that whenever he or she requested divine help he provided diverse wonders, extending from food and water in times of need to the resurrection of the dead. They ask their readers to accept as absolute fact events that most of us find implausible.

Chronicles favor the mundane, but many incorporate miracle stories, and they typically lack two qualities that modern readers require of a proper historical text: "narrativity" and a metahistorical voice. That is, their authors fail to guide their readers with comments that point them toward a particular interpretation—they fail to connect events in ways that tell stories and explain how one gave rise to the next. The third type, on the other hand, has these "missing" elements in excess.

Rhetorical histories like Luidprand of Cremona's *Antapodosis* or "Tit-for-Tat" (ca. 950), or the history of Norman Sicily attributed to "Hugo Falcandus" (ca. 1175?) are full of reflexive comments. Their authors are continually telling their audiences how to read their narratives. They often reveal immense learning and a degree of critical intelligence, but they rarely use these faculties for serious research. They favour fantasy, gossip, and slander. These texts are fact-light but spin-heavy. Thus, whereas the chronicles are often derided for being stupid and random, the rhetorical histories are slammed for being biased and deceitful.

Some scholars would like to see the rhetorical histories as a more advanced type, to argue that the form evolved out of the chronicle and that it represents a step toward the modern historical monograph; but it is difficult to construe dishonesty as "progress," and in any case, all three types thrived simultaneously. The saints' life and the chronicle did not give way to the monograph—not in the Middle Ages, at any rate. There are examples, indeed, of leading intellectuals who worked in all three modes. William of Malmesbury (d. 1143?), for example, wrote three rhetorical histories, five saints' lives, and at least two sets of annals.

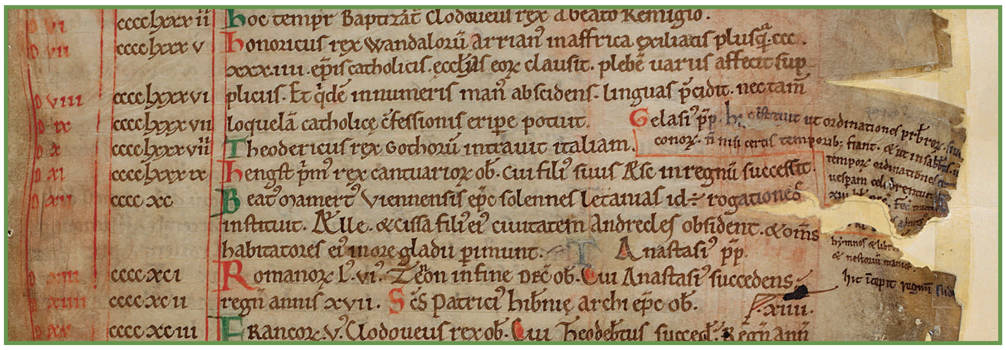


A leaf from the Later Winchcombe Annals *(London, British Library, MS Cotton Faustina B.I, fol. 23v). The layout of these annals—the wide margins that have been left for the insertion of alternative versions of the items listed in the central panel—suggests that this is a working draft. Yet, the presence of decoration—of highlights, rubricated initials, and illustrations—implies that this copy was intended to endure. It follows that the many contradictions between the core and the items in the margins were to be left unresolved.*

One might wish for better sources, but these are the sorts of history that the medieval world produced, and making them work for us presents a stimulating challenge. If we are to make sound use of them, we need to grasp the cultural systems and practices that governed their production and consumption. We cannot escape the need to look for nuggets of fact, but recognizing them and utilizing them to good effect requires sensitivity to the criteria by which medieval authors selected and adapted them for inclusion in their histories.

Many scholars now recognize, however, that the writing of a historical text is itself an event, one that can be perceived with greater certainty than those that have traditionally occupied the attention of historians—the many "mainstream" phenomena known only at considerable remove, as refracted through the distorting lenses of the texts. By investigating these texts as acts of scholarship and as oratory or propaganda we can gain genuine insights into the life and preoccupations of the communities that produced and used them.

This is especially true when the authors' working practices can be reconstructed in detail. For this purpose, it is sometimes the earlier sections of the texts—those that cover periods remote from their authors' own time—that reveal the most, in part because it was frequently risky to write explicitly about the present, but also because it is often possible to tell exactly what material was available for the researching of these sections and how the author has adapted it to suit his purposes. Thus, contrary to expectations, it is sometimes what eleventh- or twelfth-century historians report about the ancient and early medieval worlds rather than their own time that reveals most about their methods and concerns.



A detail from the Winchcombe Annals *(London, British Library, MS Cotton Tiberius E.IV, fol. 8r). The addition in the righthand margin, linked by its initial to the year AD 487, describes how Pope Gelasius provided for the ordination of priests and deacons during the four ember weeks. It is one of around ninety entries recording papal deeds that were added to the core text of this chronicle in the 1140s, almost as soon as it was made.*

It is sometimes the earlier sections of the texts—those that cover periods remote from their authors' own time—that reveal the most, in part because it was frequently risky to write explicitly about the present, but also because it is often possible to tell exactly what material was available for the researching of these sections and how the author has adapted it to suit his purposes. It is sometimes what eleventh- or twelfth-century historians report about the ancient and early medieval worlds rather than their own time that reveals most about their methods and concerns.

The possibility of achieving sound results with this sort of inquiry has advanced greatly in recent decades as scholars have discovered and published many texts that were previously unavailable (or at best only in incomplete editions), as they have defined and traced the contents of particular medieval libraries, and with the creation of vast digital databases that allow us to identify what sources were being used. Access to a powerful array of such tools is just one of the advantages that Princeton University and the Institute for Advanced Study offer to scholars working in this area.

For the past decade, I have been studying various histories produced in the eleventh and twelfth centuries with a view to comprehending the full range of historical practice in this period. The subject of my present project at IAS is a set of chronicles, drawn from many parts of Europe, which are united by an interest in a particular topic: how the first eighty or so popes created the institutions of the Church, especially its liturgy. The emergence of this theme offers telling insights into the processes that governed the composition of this type of history.

The chroniclers' interest in the topic cannot be explained by postulating a single text on which all the others depend or as a function of the operation of a cultural framework or *mentalité*. To be sure, some shared habits of mind and sources of material were involved. As clergymen or monks, all the authors had vocational reasons for being interested in the origins of the Church. All of them took data from a collection of papal biographies known as the *Liber pontificalis* and from a book of ecclesiastical law known as the "False Decretals of Pseudo-Isidore." But these sources had long been available: the former had been circulating since the sixth century, the latter since the ninth. Why then is it only from the late eleventh that the compilers of this type of history begin to research this theme, and why in so many different places at the same time?

Part of the explanation lies in the immense impact of the papal reform movement, yet not all of these chroniclers sympathized with this cause. Rather, many were induced to take a serious interest in the papacy's role in the early history of the Church by works about the liturgy and canon law that were produced in the 1090s by adherents of the movement. These works may not have won many converts among our chroniclers, but they appear to have inspired them to research this topic for the sake of their projects. The implication is that the processes involved in constructing this type of history, far from being "stupid and random," could instead be sophisticated and purposeful. ■

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under five years. "He was in the right place at the right time with the right connections with the right idea," remembers Willis Ware, fourth to be hired to join the engineering team, "setting aside the hassle that will probably never be resolved as to whose ideas they really were."

As World War II drew to a close, the scientists who had built the atomic bomb at Los Alamos wondered, "What's next?" Some, including Richard Feynman, vowed never to have anything to do with nuclear weapons or military secrecy again. Others, including Edward Teller and John von Neumann, were eager to develop more advanced nuclear weapons, especially the "Super," or hydrogen bomb. Just before dawn on the morning of July 16, 1945, the New Mexico desert was illuminated by an explosion "brighter than a thousand suns." Eight and a half years later, an explosion one thousand times more powerful illuminated the skies over Bikini Atoll. The race to build the hydrogen bomb was accelerated by von Neumann's desire to build a computer, and the push to build von Neumann's computer was accelerated by the race to build a hydrogen bomb.

In 1956, at the age of three, I was walking home with my father, physicist Freeman Dyson, from his office at the Institute for Advanced Study in Princeton, New Jersey, when I found a broken fan belt lying in the road. I asked my father what it was. "It's a piece of the sun," he said.

My father was a field theorist, and protégé of Hans Bethe, former wartime leader of the Theoretical Division at Los Alamos, who, when accepting his Nobel Prize for discovering the carbon cycle that fuels the stars, explained that "stars have a life cycle much like animals. They get born, they grow, they go through a definite internal development, and finally they die, to give back the material of which they are made so that new stars may live." To an engineer, fan belts exist between the crankshaft and the water pump. To a physicist, fan belts exist, briefly, in the intervals between stars.

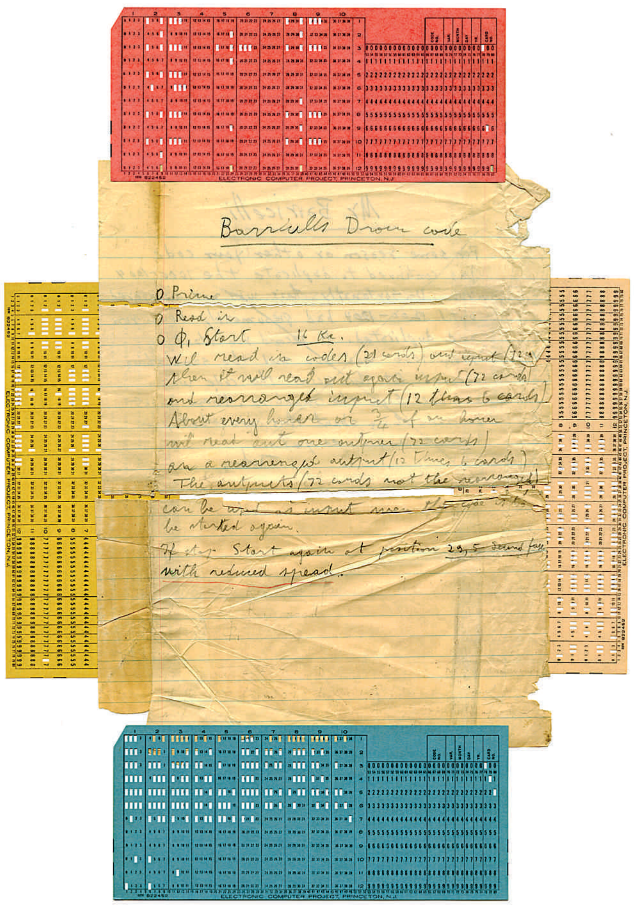
At the Institute for Advanced Study, more people worked on quantum mechanics than on their own cars. There was one notable exception: Julian Bigelow, who arrived at the Institute, in 1946, as John von Neumann's chief engineer. Bigelow, who was fluent in physics, mathematics, and electronics, was also a mechanic who could explain, even to a three-year-old, how a fan belt works, why it broke, and whether it came from a Ford or a Chevrolet.

At 10:38 p.m. on March 3, 1953, in a one-story brick building at the end of Olden Lane in Princeton, New Jersey, Italian-Norwegian mathematical biologist Nils Aall Barricelli inoculated a 5-kilobyte digital universe with random numbers generated by drawing playing cards from a shuffled deck. "A series of numerical experiments are being made with the aim of verifying the possibility of an evolution similar to that of living organisms taking place in an artificially created universe," he announced.

A digital universe—whether 5 kilobytes or the entire Internet—consists of two species of bits: differences in space, and differences in time. Digital computers translate between these two forms of information—structure and sequence—according to definite rules. Bits that are embodied as structure (varying in space, invariant across time) we perceive as memory, and bits that are embodied in sequence (varying in time, invariant across space) we perceive as code. Gates are the intersections where bits span both worlds at the moments of transition from one instant to the next.

The term *bit* (the contraction, by 40 bits, of *binary digit*) was coined by statistician John W. Tukey shortly after he joined von Neumann's project in November of 1945. The existence of a fundamental unit of communicable information, representing a single distinction between two alternatives, was defined rigorously by information theorist Claude Shannon in his then-secret *Mathematical Theory of Cryptography* of 1945, expanded into his *Mathematical Theory of Communication* of 1948. "Any difference that makes a difference" is how cybernetician Gregory Bateson translated Shannon's definition into informal terms. To a digital computer, the only difference that makes a difference is the difference between a zero and a one.

In March of 1953 there were 53 kilobytes of high-speed random-access memory on planet Earth. Five kilobytes were at the end of Olden Lane, 32 kilobytes were divided among the eight completed clones of the Institute for Advanced Study's computer, and 16 kilobytes were unevenly distributed across a half dozen other machines. Data, and the few rudimentary programs that existed, were exchanged at the speed of punched cards and paper tape. Each island in the new archipelago constituted a universe unto itself.



INSTITUTE FOR ADVANCED STUDY

Handwritten note and examples of punch cards related to Nils Barricelli's work using the computer

In 1936, logician Alan Turing had formalized the powers (and limitations) of digital computers by giving a precise description of a class of devices (including an obedient human being) that could read, write, remember, and erase marks on an unbounded supply of tape. These "Turing machines" were able to translate, in both directions, between bits embodied as structure (in space) and bits encoded as sequences (in time). Turing then demonstrated the existence of a Universal Computing Machine that, given sufficient time, sufficient tape, and a precise description, could emulate the behavior of any other computing machine. The results are independent of whether the instructions are executed by tennis balls or electrons, and whether the memory is stored in semiconductors or on paper tape. "Being digital should be of more interest than being electronic," Turing pointed out.

Von Neumann set out to build a Universal Turing Machine that would operate at electronic speeds. At its core was a 32-by-32-by-40-bit matrix of high-speed random-access memory—the nucleus of all things digital ever since. "Random-access" meant that all individual memory locations—collectively constituting the machine's internal "state of mind"—were equally accessible at any time. "High speed" meant that the memory was accessible at the speed of light, not the speed of sound. It was the removal of this constraint that unleashed the powers of Turing's otherwise impractical Universal Machine.

The IAS computer incorporated a bank of forty cathode-ray memory tubes, with memory addresses assigned as if a desk clerk were handing out similar room numbers to forty guests at a time in a forty-floor hotel. Codes proliferated within this universe by taking advantage of the architectural principle that a pair of 5-bit coordinates ($2^5 = 32$) uniquely identified one of 1,024 memory locations containing a string (or "word") of 40 bits. In 24 microseconds, any specified 40-bit string of code could be retrieved. These 40 bits could include not only data (numbers that mean things) but also executable instructions (numbers that do things)—including instructions to modify the existing instructions, or transfer control to another location and follow new instructions from there.

Since a 10-bit order code, combined with 10 bits specifying a memory address, returned a string of 40 bits, the result was a chain reaction, analogous to the two-for-one fission of neutrons within the core of an atomic bomb. All hell broke loose as a result. Random-access memory gave the world of machines access to the powers of numbers—and gave the world of numbers access to the powers of machines.

At the Institute for Advanced Study in early 1946, even applied mathematics was out of bounds. Mathematicians who had worked on applications during the war were expected to leave them behind. Von Neumann, however, was hooked. "When the war was over, and scientists were migrating back to their respective Universities or research institutions, Johnny returned to the Institute in Princeton," Klári [von Neumann] recalls. "There he clearly stunned, or even horrified, some of his mathematical colleagues of the most erudite abstraction, by openly professing his great interest in other mathematical tools than the blackboard and chalk or pencil and paper." His proposal to build an electronic computing machine under the sacred dome of the Institute was not received with applause to say the least. It wasn't just the pure mathematicians who were disturbed by the prospect of the computer. The humanists had been holding their ground against the mathematicians as best they could, and von Neumann's project, set to triple the budget of the School of Mathematics, was suspect on that count alone. "Mathematicians in our wing? Over my dead body! And yours?" [IAS Director Frank] Aydelotte was cabled by paleographer Elias Lowe.

Aydelotte, however, was ready to do anything to retain von Neumann, and supported the Institute's taking an active role in experimental research. The scientists who had been sequestered at Los Alamos during the war, with an unlimited research budget and no teaching obligations, were now returning in large numbers to their positions on the East Coast. A consortium of thirteen institutions petitioned General Leslie Groves, former commander of the Manhattan Project, to establish a new nuclear research laboratory that would be the Los Alamos of the East. Aydelotte supported the proposal and even suggested building the new laboratory in the Institute Woods. "We would have an ideal location for it and I could hardly think of any place in the east that would be more convenient," Aydelotte, en route to Palestine, cabled von Neumann from on board the *Queen Elizabeth*. At a meeting of the School of Mathematics called to discuss the proposal, the strongest dissenting voice was Albert Einstein, who, the minutes record, "emphasizes the dangers of secret war work" and "fears the emphasis on such projects will further ideas of 'preventive' wars." Aydelotte and von Neumann hoped the computer project would get the Institute's foot in the door for lucrative government contract work—just what Einstein feared.

Aydelotte pressed for a proposed budget, and von Neumann answered, "about $100,000 per year for three years for the construction of an all-purpose, automatic, electronic computing machine." He argued that "it is most important that a purely scientific organization should undertake such a project," since the government laboratories were only building devices for "definite, often very specialized purposes," and "any industrial company, on the other hand, which undertakes such a venture would be influenced by its own past procedures and routines, and it would therefore not be able to make as fresh a start."

In September of 1930, at the Königsberg conference on the epistemology of the exact sciences, [Kurt] Gödel made the first, tentative announcement of his incompleteness results. Von Neumann immediately saw the implications, and, as he wrote to Gödel on November 30, 1930, "using the methods you employed so successfully … I achieved a result that seems to me to be remarkable, namely, I was able to show that the consistency of mathematics is unprovable," only to find out, by return mail, that Gödel had got there first. "He was disappointed that he had not first discovered Gödel's undecidability theorems," explains [Stan] Ulam. "He was more than capable of this, had he admitted to himself the possibility that [David] Hilbert was wrong in his program. But it would have meant going against the prevailing thinking of the time."

Von Neumann remained a vocal supporter of Gödel—whose results he recognized as applying to "all systems which permit a formalization"—and never worked on the foundations of mathematics again. "Gödel's achievement in modern logic is singular and monumental … a landmark which will remain visible far in space and time," he noted. "The result is remarkable in its quasi-paradoxical 'self-denial': It will never be possible to acquire with mathematical means the certainty that mathematics does not contain contradictions … The subject of logic will never again be the same."

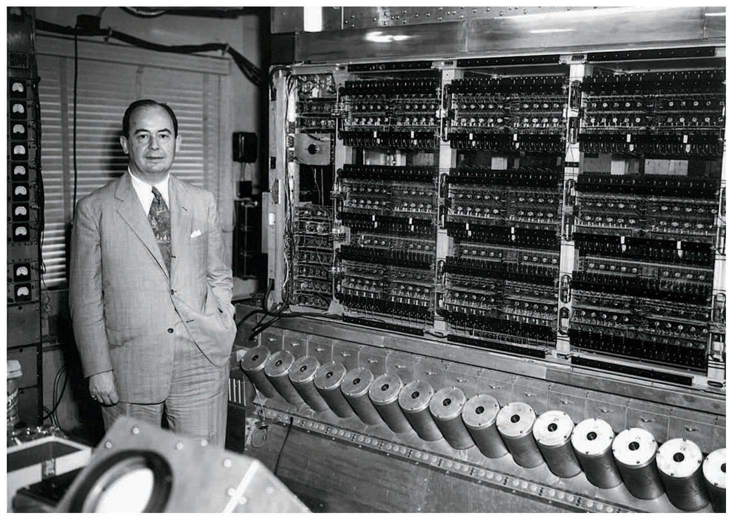
Gödel set the stage for the digital revolution, not only by redefining the powers of formal systems—and lining things up for their physical embodiment by Alan Turing—but by steering von Neumann's interests from pure logic to applied. It was while attempting to extend Gödel's results to a more general solution of Hilbert's *Entscheidungsproblem*—the "decision problem" of whether provable statements can be distinguished from disprovable statements by strictly mechanical procedures in a finite amount of time—that Turing invented his Universal Machine. All the powers—and limits to those powers—that Gödel's theorems assigned to formal systems also applied to Turing's Universal Machine, including the version that von Neumann, from his office directly below Gödel's, was now attempting to build.

Gödel assigned all expressions within the language of the given formal system unique identity numbers—or numerical addresses—forcing them into correspondence with a numerical bureaucracy from which it was impossible to escape. The Gödel numbering is based on an alphabet of primes, with an explicit coding mechanism governing translation between compound expressions and their Gödel numbers—similar to, but without the ambiguity that characterizes the translations from nucleotides to amino acids upon which protein synthesis is based. This representation of all possible concepts by numerical codes seemed to be a purely theoretical construct in 1931.

In 1679, [Gottfried Wilhelm] Leibniz imagined a digital computer in which binary numbers were represented by spherical tokens, governed by gates under mechanical control. "This [binary] calculus could be implemented by a machine (without wheels)," he wrote, "in the following manner, easily to be sure and without effort. A container shall be provided with holes in such a way that they can be opened and closed. They are to be open at those places that correspond to a 1 and remain closed at those that correspond to a 0. Through the opened gates small cubes or marbles are to fall into tracks, through the others nothing. It [the gate array] is to be shifted from column to column as required."

Leibniz had invented the shift register—270 years ahead of its time. In the shift registers at the heart of the Institute for Advanced Study computer (and all processors and microprocessors since), voltage gradients and pulses of electrons have taken the place of gravity and marbles, but otherwise they operate as Leibniz envisioned in 1679. With nothing more than binary tokens, and the ability to shift right and left, it is possible to perform all the functions of arithmetic. But to do anything with that arithmetic, you have to be able to store and recall the results.

"There are two possible means for storing a particular word in the Selectron memory," [Arthur] Burks, [Herman] Goldstine, and von Neumann explained. "One method is to store the entire word in a given tube and … the other method is to store in corresponding places in each of the 40 tubes one digit of the word." This was the origin of the metaphor of handing out similar room numbers to 40 people staying in a 40-floor hotel. "To get a word from the memory in this scheme requires, then, one switching mechanism to which all 40 tubes are connected in parallel," their "Preliminary Discussion" continues. "Such a switching scheme seems to us to be simpler than the technique needed in the serial system and is, of course, 40 times faster. The essential difference between these two systems lies in the method of performing an addition; in a parallel machine all corresponding pairs of digits are added simultaneously, whereas in a serial one these pairs are added serially in time."



INSTITUTE FOR ADVANCED STUDY

John von Neumann in front of the IAS computer, 1952. At waist level are twelve of the forty Williams cathode-ray memory tubes, storing 1,024 bits in each individual tube, for a total capacity of five kilobytes (40,960 bits).

The 40 Selectron tubes constituted a 32-by-32-by-40-bit matrix containing 1,024 40-bit strings of code, with each string assigned a unique identity number, or numerical address, in a manner reminiscent of how Gödel had assigned what are now called Gödel numbers to logical statements in 1931. By manipulating the 10-bit addresses, it was possible to manipulate the underlying 40-bit strings—containing any desired combination of data, instructions, or additional addresses, all modifiable by the progress of the program being executed at the time. "This ability of the machine to modify its own orders is one of the things which makes coding the non-trivial operation which we have to view it as," von Neumann explained to his navy sponsors in May of 1946.

"The kind of thinking that Gödel was doing, things like Gödel numbering systems—ways of getting access to codified information and such—enables you to keep track of the parcels of information as they are formed, and … you can then deduce certain important consequences," says Bigelow. "I think those ideas were very well known to von Neumann [who] spent a fair amount of his time trying to do mathematical logic, and he worked on the same problem that Gödel solved."

The logical architecture of the IAS computer, foreshadowed by Gödel, was formulated in Fuld 219.

Using the same method of logical substitution by which a Turing machine can be instructed to interpret successively higher-level languages—or by which Gödel was able to encode metamathematical statements within ordinary arithmetic—it was possible to design Turing machines whose coded instructions addressed physical components, not memory locations, and whose output could be translated into physical objects, not just zeros and ones. "Small variations of the foregoing scheme," von Neumann continued, "also permit us to construct automata which can reproduce themselves and, in addition, construct others." Von Neumann compared the behavior of such automata to what, in biology, characterizes the "typical gene function, self-reproduction plus production—or stimulation of production—of certain specific enzymes."

Recommended Viewing: A video of a recent talk at IAS by George Dyson may be viewed at http://video.ias.edu/dyson-talk-3-12.

Von Neumann made a deal with "the other party" in 1946. The scientists would get the computers, and the military would get the bombs. This seems to have turned out well enough so far, because, contrary to von Neumann's expectations, it was the computers that exploded, not the bombs.

"It is possible that in later years the machine sizes will increase again, but it is not likely that 10,000 (or perhaps a few times 10,000) switching organs will be exceeded as long as the present techniques and philosophy are employed," von Neumann predicted in 1948. "About 10,000 switching organs seem to be the proper order of magnitude for a computing machine." The transistor had just been invented, and it would be another six years before you could buy a transistor radio—with four transistors. In 2010 you could buy a computer with a billion transistors for the inflation-adjusted cost of a transistor radio in 1956.

Von Neumann's estimate was off by over five orders of magnitude—so far. He believed, and counseled the government and industry strategists who sought his advice, that a small number of large computers would be able to meet the demand for high-speed computing, once the impediments to remote input and output were addressed. This was true, but only for a very short time. After concentrating briefly in large, centralized computing facilities, the detonation wave that began with punched cards and vacuum tubes was propagated across a series of material and institutional boundaries: into magnetic-core memory, semiconductors, integrated circuits, and microprocessors; and from mainframes and time-sharing systems into minicomputers, microcomputers, personal computers, the branching reaches of the Internet, and now billions of embedded microprocessors and aptly named cell phones. As components grew larger in number, they grew smaller in size and cycled faster in time. The world was transformed. ■

Excerpted from Turing's Cathedral: The Origins of the Digital Universe *by George Dyson © 2012, reprinted by arrangement with Pantheon Books, an imprint of the Knopf Doubleday Publishing Group, a division of Random House, Inc.*

George Dyson is a historian of science and technology and the son of Freeman Dyson, Professor Emeritus in the School of Natural Sciences. He grew up at the Institute and attended Princeton High School before leaving home at sixteen and moving to British Columbia, where he developed both theoretical and practical knowledge of the Aleutian kayak, the subject of his first book. He began writing Turing's Cathedral *while a Director's Visitor at the Institute (2002–03), and notes that "the entire Electronic Computer Project was completed in less time than it took me to write about it." He will receive an Honorary Doctor of Laws from the University of Victoria in December.*

 (Continued from page 1)

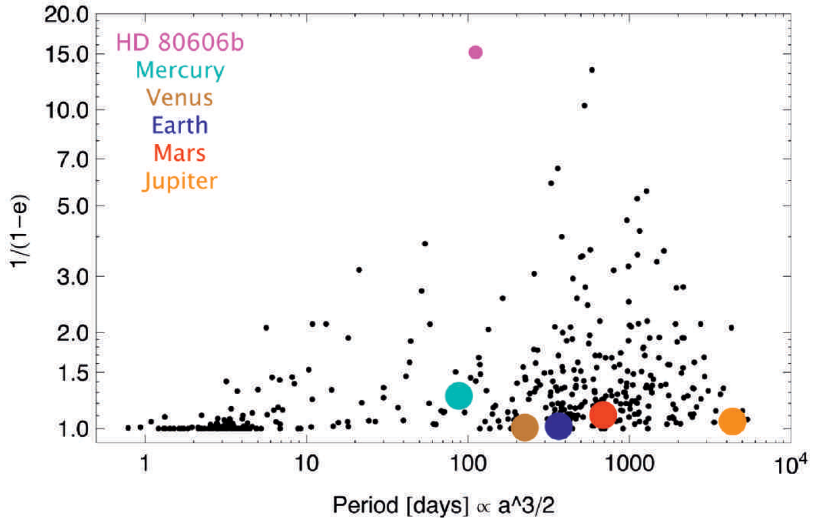


Figure 1: A measure of eccentricity e versus orbital period for gas giant extrasolar planets, i.e., planets like our Jupiter and Saturn. The inner five planets of our solar system are included as well. In general, the physical processes that lead to planet formation produce solar systems that are unlike our own. The overwhelming majority of the planets depicted in this graph orbit Sun-like stars. (Data: www.exoplanets.org)

clusters of galaxies, cosmic microwave background radiation, and the list goes on.

The general pursuit of the twentieth century continues with the planned construction of the billion-dollar-plus U.S.-led Giant Magellan and Thirty-Meter Telescopes, as well as the European Extremely Large Telescope. However, a new strategy for discovery has emerged in the twenty-first century: time-domain astronomy. Rather than finding faint and distant sources, searching in the time-domain enables the discovery, for instance, of small variations of relatively bright nearby objects, such as stars. An exciting source of such small brightness variations are extrasolar planets or, in other words, planets that orbit around other stars.

The basic approach of time-domain astronomy is easy enough to state. Look somewhere in the sky and then look at it again, some time later. If anything has changed, study it further. The time it takes for the instrument to reobserve the same patch of sky is referred to as the "cadence." By using the old strategy of looking deep and far into the Universe, sources of a given brightness are methodically mapped out in a three-dimensional volume. In time-domain astronomy, sources that vary by some brightness with a rate equal to the inverse of the instrument cadence can be steadily mapped out. In a way, the time-domain adds another dimension, given by the frequency equal to the inverse cadence, to the properties of observed phenomena.

Interestingly, one can either go deep with a relatively big telescope, coming back to the same field of view every once in a while, or one can go shallow with a relatively small telescope and a short cadence. Since we don't know what's out there, each approach seems equally valid.

An important point to keep in mind: small telescopes typically have relatively large fields of view in comparison to big telescopes. Since small telescopes are much cheaper to construct than big telescopes, the cost of mapping out the Universe in the time-domain may be done more efficiently with smaller instruments that have rapid cadence. Perhaps the next century of astronomical discovery will be dominated by several small groups of enterprising individuals, armed with batteries of modest telescopes, competing with one another to map out the time-domain. For years, such a view of astronomy's future was enthusiastically advocated by the late Bohdan Paczynski of Princeton University (a frequent Visitor in the School of Natural Sciences between 1974–81), who initiated two successful time-domain campaigns: the All-Sky Automated Survey and the Optical Gravitational Lensing Experiment.

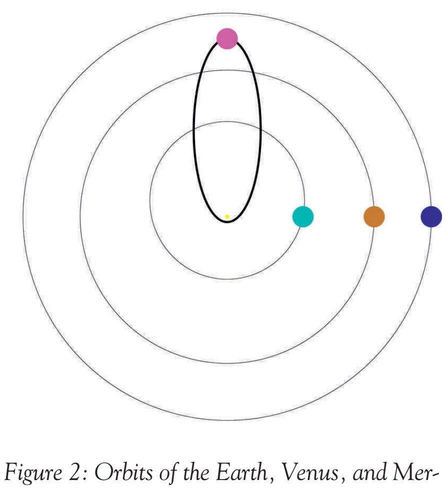


Figure 2: Orbits of the Earth, Venus, and Mercury superposed with that of HD 80606b (magenta). Not only is its orbit extreme in comparison with those of our inner-solar system, but its mass is extreme as well in that HD 80606b is a gas giant planet, like Jupiter. At closest approach, the surface temperature of HD 80606b is approximately 1500 K. The average temperature on Earth is approximately 300 K. Note that the orbit of Mercury (cyan) is moderately eccentric with e=0.2, while Earth and Venus possess nearly circular orbits.

Paczynski realized early on that the only way to achieve this was to take full advantage of astronomy's impending digitization. Modern telescopes equipped with CCD cameras (like the one in your cell phone), rather than the old photographic plates, produce pixel-by-pixel electronic images of the sky that can be stored and manipulated by a computer. Only with the help of massive amounts of custom-built software and fast processors would it be possible to explore massive volumes of the Universe in the time-domain with great precision.

Consider repeatedly scanning a huge number of Sun-like stars in the Milky Way with high cadence at great precision, in order to look for small differences in their emitted light. As previously mentioned, an interesting source of such small differences may be a planet that orbits around its host star, i.e., an extrasolar planet. In the case where a planet passes in front of its host, a small (about 1 percent for a big planet) momentary depression in its brightness, or an eclipse, can be observed. Such an eclipse is usually referred to as a "transit" and is one of the most successful methods of detecting extrasolar planets. Today, we know the properties of approximately 1,000 extrasolar planets. Twenty years ago, at the beginning of the digital age, that number was zero. Paczynksi was right.

The primary motivation for studying extrasolar planets is to find another place in the Universe that closely resembles our own planet, i.e., another Earth. Since an Earth-sized planet is quite small in both size and mass in comparison to its stellar host, its ability to deform the appearance of its host is correspondingly limited. Its transit in front of a Sun-like star would lead to a depression in brightness that is of order 1 percent of 1 percent. Only now are instruments sensitive enough to detect an Earth analogue. If they are out there in significant number, the recently launched Kepler space observatory, a high-precision extra-solar-planet-transit-detecting-machine, should report on their discovery any day now.

But, what about the 1,000 or so extrasolar planets whose properties (mass, radius, orbit, etc.) we know of? Figure 1 clearly shows that other solar systems are commonly quite unlike our own.

The shape of a planet's orbit is well approximated by an ellipse where the stellar host resides at one of the focus points (see box, right). In the limit that the ellipse is a perfect circle, the eccentricity e is equal to zero, and in the other extreme, where the orbit is a parabola, e is equal to one. Figure 1 tells us that, unlike our solar system, the eccentricity of big planets, like our Jupiter, can take on almost any value. Note the magenta point in Figure 1, which depicts HD 80606b, the most eccentric planet known to date, with e=0.93! Figure 2 depicts what its orbit would look like if it were placed in our solar system.

The Keplerian Orbit

Johannes Kepler realized that the shape of a planet's orbit about the sun was given by an ellipse, rather than a circle. Newton realized that such a shape followed directly from the (his) laws of motion, given that the gravitational force between any two objects varies with the inverse square of their distance. For a Keplerian orbit, the orbital period P is related to the semi-major axis a by

$$P^2 \propto a^3,$$

the angular momentum of the orbit J is related to the semi-major axis a and eccentricity e

$$J^2 \propto a\left(1-e^2\right) = r_p\left(1+e\right)$$

where r_p is the distance of closest approach (the periastron). The energy E of the orbit is negative and follows

$$E \propto 1/a.$$

The eccentricity of an ellipse is given by

$$e = \sqrt{1 - b^2/a^2}$$

where b is the semi-minor axis of the ellipse.

It is generally presumed that gas giants are formed at large separation from their host stars. Therefore, the cluster of gas giant planets with short orbital periods, known as the "hot Jupiters," in Figure 1 came as quite a surprise. In order to account for their close-in orbits, the concept of "migration" is often invoked, meaning the planet was formed far away from its stellar host and then some mechanism removed its orbital energy such that its average heliocentric distance was reduced by a factor of 100 or more. Such a notion seems unbelievable, but the fact that the hot Jupiters exist in relatively large numbers (about 1 percent of all Sun-like stars have one) forces us to seriously consider it.

A popular class of hot Jupiter migration scenarios involves the introduction of a third body, such as another giant planet or a stellar companion (about half of all stars are in binaries). The gravitational interaction between the third body and a gas giant can exchange orbital angular momentum, but roughly conserves orbital energy. In the event that most of the angular momentum is extracted from the gas giant's orbit, the eccentricity becomes large and the distance of closest approach, called "periastron," becomes very small, much like HD 80606b.

As the planet comes toward periastron, the tides raised on the planet rapidly increase in strength. In fact, the height of the tide increases with the inverse of distance, cubed. The energy stored in the tidal flow increases with the inverse of distance to the sixth power. Tidal friction during closest approach then allows energy to be drained from the orbit and converted into some form of heat within the planet, which is then radiated into outer space. Consequently, the average heliocentric distance slowly shrinks as a result of tidal friction such that a gas giant with an initial period of several years ends up in a circular orbit with a final period of a few days where migration ends (see Figure 3, page 11). Such a

Basic Assumptions

The angular momentum in the orbit is much greater than the spin angular momentum of the planet. So to first approximation, the orbital angular momentum J remains fixed during evolution

$$J^2 \propto a\left(1-e^2\right) = r_p(1+e) = \text{cst}.$$

If the planets are formed in a steady state, the continuity relation that describes their distribution N satisfies

$$\dot{a}\,\frac{dN}{da} = S$$

where S is a constant that specifies the rate at which gas giant planets are formed at large orbital separation, presumably far from the region under consideration.

Orbital Evolution: A Simple Result

For high values of eccentricity e the shape of the orbit near periastron is a parabola. Consequently, the energy loss per periastron passage ΔE is independent of e in the high-e regime. It follows that for super-eccentric orbits, the rate at which tidal friction drains the orbital energy is given by

$$\dot{E} = \frac{\Delta E}{P} \propto \frac{1}{P} \propto a^{-3/2}$$

where P is the orbital period. Since $E \propto 1/a$

$$\left|\frac{da}{dt}\right| \equiv \dot{a} \propto a^{1/2}.$$

By inserting this into the continuity relation we can solve for the number distribution N of planets at a given semi-major axis

$$a\,\frac{dN}{da} = \frac{a}{\dot{a}} \propto a^{1/2} \propto P^{1/3}$$

or in other words, there should be an increasing number of super-eccentric planets with increasing orbital periods.

More details can be found in our paper, located at http://arxiv.org/abs/1110.1644.

What Do Judges Do?

BY W. BENTLEY MACLEOD

In 2003, the Supreme Court of the United States heard the case of *Grutter v. Bollinger* and upheld the right of the University of Michigan Law School to use race as a criterion for admissions. At the time, the majority speculated that in twenty-five years the consideration of race may no longer be necessary in admissions. This year, the Supreme Court will hear the case of *Fisher v. University of Texas*, which turns on the same issue. In other words, we may have a change in the law in less than ten years!

This, like many decisions of the Supreme Court, can have a major impact on our day-to-day lives. The decision in this case affects the set of schools to which we may be admitted in a world where access to the best schools is considered by many to be an important career stepping stone. The more puzzling aspect, particularly for non-Americans, is that this change does not result from any change in the law enacted by Congress. Both cases appeal to two laws. The first is constitutional law, namely the Fourteenth Amendment, which ensures that all citizens have equal protection under the law. The second is a statute passed by Congress, Title VI of the Civil Rights Act of 1964, which bans discrimination by agencies that receive federal funds. In *Grutter v. Bollinger* the judges created new law. They argued that the state had a *compelling interest* in allowing schools to use race as a factor in admissions. In essence, judges, rather than elected politicians, created a new law that allows universities to choose students on a basis that is arguably inconsistent with the Constitution of the United States.

ANDREA KANE

W. Bentley MacLeod, Leon Levy Foundation Member (2011–12) in the School of Social Science and Sami Mnaymneh Professor of Economics and Professor of International and Public Affairs at Columbia University, studies the design of contracts for the supply of complex goods and services, particularly labor and education.

The enormous power of the Supreme Court raises questions about what judges do, and how they reach such momentous decisions. In February, the economics workshop at the Institute for Advanced Study brought together three leading experts to discuss these issues. The subject is of interest to economists because the rule of law is considered to be an essential ingredient for successful economic growth. Courts are regularly called on to make decisions with large economic consequences, such as deciding on liability for the losses arising from the September 11 attacks, and whether or not Obamacare is constitutional. Our goal is to understand the process by which these decisions are made.

The session began with Charles Cameron of the Department of Politics at Princeton University and Lewis Kornhauser of the New York University School of Law who presented work for their book project, which builds on a seminal paper by Kornhauser, "Modeling Collegial Courts II: Legal Doctrine," published in 1992 in the *Journal of Law, Economics and Organization*. The book is concerned with how courts make decisions. As a problem of collective decision-making, court systems are both sufficiently complicated to combine many problems such as hierarchy and collegiality that appear in many more complex environments and sufficiently simple that we have some hope of understanding them. The long-term goal is to provide a micro foundation of judicial decision-making that may shed light on the macro questions of the role of law in economic growth.

The discussion began with a brief review by Cameron and Kornhauser of what the courts do. The main goal of a court is to resolve a dispute. When a case is brought before a court, a decision must be made in favor of one party or the other. The significance of this is that courts must render judgment or make a decision, even when they are uncertain of the correct outcome or how to apply the law in a particular case. This results in courts having two roles.

The first role is like that of a bureaucrat. Judges apply legal rules to the evidence before them. The difficulty is that the law is not always clear. For economists, the fact that rules are not clear is analogous to the problem of incomplete markets that leads to, among other things, meltdowns in financial markets. Over time, the common-law system evolved a second role for judges. Namely, the judgments they render have the force of law that binds in future cases (so-called *stare decisis*).

Legislators cannot anticipate all actions by parties in the future, and hence there will be times when it is not clear how to apply a rule. In a civil-law jurisdiction, judges apply the law as best they can. However, the reasoning underlying a decision for a case is typically not recorded, and cannot be used in a future case. In contrast, in a common-law jurisdiction, the reasoning of appellate courts is recorded and can be cited by future cases. Cameron and Kornhauser advocate a "case-based" approach to judicial decision-making. The basic idea is that previous cases and the evidence before them constrain judges' behavior in predictable ways. They explain that the Supreme Court is revisiting *Grutter v. Bollinger* because the environment has changed, and there may no longer be a compelling public interest in providing an exception to the Fourteenth Amendment.

Nolan McCarty, Cameron's colleague and Chair of the Department of Political Science at Princeton, argued that an alternative "policy-space" approach "is a more useful and parsimonious model." The idea is that judges have explicit preferences over outcomes, and then make choices that achieve these outcomes, with the law and future legislation providing a constraint on this behavior. As I write this, we do not know how the courts will decide the case of *Fisher v. University of Texas*; however, the policy-space approach would predict that if the decision changes, it will be due to the fact that the Court is now more conservative, rather than a change in the facts of the case.

There is some evidence to show that the political views of judges do have an effect on outcomes. Yet a well-functioning legal system requires predictability and that judges rule for the most part in ways that are consistent with the law. Thus, in practice, the effects of both case-based and policy-space approaches are present. The discussion concluded that an important open question is the extent to which the discretion of judges should be limited. Some systems, such as civil-law jurisdictions, explicitly try to limit the power of judges. In other systems, such as in soccer, the judge/referee has the ultimate authority to decide as he or she wishes, with effectively no system of appeals.

In contrast to a court case where a judge is required to reach a decision, we were not required to reach a consensus. Rather, the seminar ended with the case undecided and a call for future research, an activity for which the Institute for Advanced Study is well suited. ■

EXTRASOLAR PLANETS *(Continued from page 10)*

process within a solar system seems unbelievable, but again, the observations require that we seriously consider it.

IAS Members Subo Dong and Boaz Katz, Professor Scott Tremaine, and I have proposed a simple test of this "high-*e*" migration scenario. Our arguments begin with a rather unsophisticated fact: stars in the Milky Way are formed roughly in a steady state shortly after the birth of the Universe. Since planet formation is a byproduct of star formation, planets are therefore formed in a steady state as well. So, if we see some number of gas giant planets with moderate eccentricities that may end up becoming short-period hot Jupiters, we should see many super-eccentric gas giants on their way in (see box, page 10, bottom right). In fact, for every HD 80606b, there should be several gas giant planets with record-breaking eccentricities. One reason why these super-eccentric Jupiters have not been detected so far may be due to previous limitations in detector sensitivity and observational strategy. Interestingly, the Kepler space observatory does not suffer from such deficiencies, and we predict that it should detect anywhere from a handful to a dozen super-eccentric gas giant planets if high-*e* migration is at work.

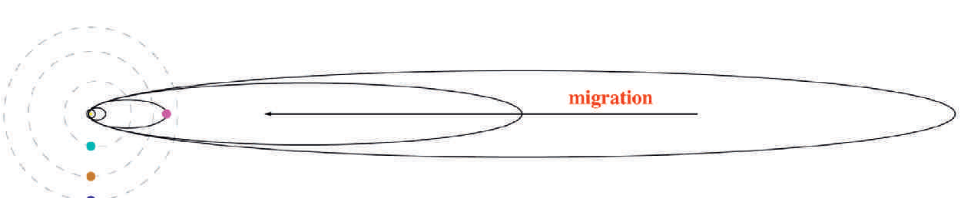


Figure 3: Depiction of high-e migration of HD 80606b (magenta). The outer ellipse corresponds to a planet with HD 80606b's orbital angular momentum, but with an orbital period of twelve years, equal to that of our Jupiter. The sequence of ellipses of diminishing eccentricity illustrates how tidal dissipation at closest approach to the stellar host slowly removes orbital energy, shrinking the orbit, but conserving angular momentum. At the end of its migration, HD 80606b's orbit will be the small circular orbit, with a final period equal to 5 days. For reference, the orbits of the inner three planets of our solar system are shown.

In the last century, bigger and bigger telescopes were built largely to find sources of light that are far away and strange. On the way to discovering rare beasts, like quasars, we realized that we orbit a rather common star, which itself orbits within a rather common galaxy, and the Universe contains billions of each. By mapping out the vast wilderness that is the Universe, the notion that we are quite ordinary was unexpectedly reinforced.

By examining close-by stars similar to our Sun with great precision in the time-domain, the basic expectation was to find solar systems that are like our own. We now realize that the architecture of our solar system is not typical—it is only one of a vast variety of possibilities. In our attempts to confirm that there are places in the Universe like our own, we have found that the particular place we occupy is, in some ways, rather strange.

Is there any meaning to all of this? Probably. But, I am running out of space and expertise. What I can say for sure is that the Universe has a tendency to disregard our expectations. Maybe there is a lesson in that. ■

Aristotle Socrates has been a John N. Bahcall Fellow and long-term Member in the School of Natural Sciences since 2008. He is interested in high-energy astrophysics, particularly the physical processes that underlie accretion onto black holes and neutron stars. He is exploring the effects of cosmic ray production on the mass and luminosity of galaxies and their respective black holes, and studying the tidal and thermal evolution of extrasolar giant planets.

IAS/PCMI: Advancing a Common Curriculum in Mathematics

BY HERB CLEMENS

The Institute for Advanced Study's Park City Mathematics Institute (PCMI) has run a summer program for secondary school mathematics teacher-leaders since 1994. About fifty nationally selected secondary mathematics teachers participate in the three-week institute each year. Gradually over the years, the program, with its three components —doing mathematics, reflecting on practice, and becoming a resource to colleagues and the profession—has developed into one of the premier programs for the professional development of mathematics teachers in the United States. It is arguably unsurpassed in overall quality.

However, the small numbers of teachers that can be served directly by this program, together with its sizable cost (long supported by the National Science Foundation), have brought the program to a crossroads of sorts. The PCMI Secondary School Teachers Program must either increase its influence on national mathematical development at the secondary level or reduce the cost of its program and so, inevitably, its quality.

TODD ROYAL HICKEN

The PCMI Secondary School Teachers Program, whose 2011 theme was "Making Mathematical Connections," has become a premier professional-development program for math teachers.

Happily, the program arrives at this crossroads at a most fortuitous moment in our nation's educational history. The reason for this is the advent of the Common Core State Standards in Mathematics (CCSSM), a common set of norms for curriculum and practice at each grade level, that has been voluntarily agreed to by forty-four of the fifty states. (Readers wishing to familiarize themselves with the content of CCSSM are referred to www.corestandards.org.)

CCSSM is to be implemented gradually in the nation's classrooms over the coming decade. This is by far the closest our nation has ever come to national standards and a common curriculum in the teaching of mathematics. The common mathematical experience at comparable grade levels, long the practice in most other nations, is coming within reach in the United States!

The advantages in terms of coherent progressions in learning, transferable from district to district and state to state in a mobile society, are clear. The opportunities for our nation's mathematics teachers themselves are perhaps less apparent but equally real. It is in this area that the IAS Park City Mathematics Institute has a new, distinctive, and potentially influential role to play.

CCSSM sets the bar for the nation's teachers and students at the high end of the current U.S. spectrum. Many mathematics teachers are prepared and fully ready to implement the skills and practices, mathematical and pedagogical, demanded by this new "common text." But it is likely that many more are not. Add to that the fact that the number of mathematics teachers is so large that only teachers themselves can form a critical leadership mass to take on the major task of supporting their colleagues through this change. It will take sustained work of teacher-leaders with individuals and small groups of colleagues to fuel the successful implementation of CCSSM. It is precisely in the formation and sustenance of this group of teacher-leaders that the future of the IAS Park City program lies.

PCMI cannot, however, realize that future role acting alone. So it has recently partnered with Math for America, a much larger program whose national agenda for mathematics teaching is most closely aligned with that of PCMI itself. During the 2011 PCMI summer program, Math for America and PCMI convened a meeting of leaders of the major national constituencies in the teaching of mathematics. The group met around the premise that teacher leadership will have to be identified and supported for the massive professional development challenge that the advent of CCSSM represents. From this meeting, a consortium of ten organizations—made up of Math for America; PCMI; Achieve; American Federation of Teachers; Association of Mathematics Teacher-Educators; Association of State Supervisors of Mathematics; Conference Board of Mathematical Sciences; Institute of Mathematics and Education; National Council of Supervisors of Mathematics; and National Council of Teachers of Mathematics—formed an ad hoc committee to work cooperatively to help spur the development of mathematics teacher-leaders.

At least as importantly, the committee sees the implementation of the CCSSM as the vehicle toward a larger and more fundamental goal, namely the enhancement of the status of mathematics teachers themselves. The positive change in professional status would rest on the consolidation of a set of rigorous professional standards and norms, maintained and managed from within the profession itself, as is the case with other professions such as law, medicine, and higher education. One of the first actions of this ad hoc committee was to identify six national teacher-leaders to join its ranks and eight more teacher-leaders to work with the Institute of Mathematics and Education to produce a CCSSM implementation toolkit. Work on the toolkit has begun. It will be piloted in teacher professional development settings around the country in 2012, and refined by teacher teams at this summer's PCMI program. The committee itself will also reconvene at PCMI during the summer institute as well.

As an important companion-piece to these efforts on the national front, PCMI runs a one-week international seminar each summer. Through the generosity of a private donor, we learn in depth about the teaching of mathematics in other societies around the world. Each year, teams consisting of a currently practicing mathematics teacher and a developer of curriculum, education ministry official, or teacher educator from eight countries around the world come together to compare their own country's response to common educational problems with that of the other countries around the table. These seminars bring home to us the challenges that we in the United States face in order to hold our own among the large and increasing numbers of highly trained professionals in the mathematical sciences from an ever-widening spectrum of countries and cultures. What we learn from abroad, and the fact that, in the future, our nation's young people must be competitive with those international professionals and the products of their educational systems, are driving forces behind the almost universal buy-in to CCSSM by the sovereign states.

At long last our country is poised to engage in a systemic effort to face that challenge, at least when it comes to the teaching and learning of mathematics itself and the mathematical skills required by related disciplines. PCMI and Math for America are delighted to have the opportunity to host this joint effort using CCSSM as a common text. For PCMI and its Secondary School Teachers Program this signifies a once-in-a-lifetime opportunity to become a more influential contributor to the quality of mathematics teaching around the U.S.

The IAS Park City program, grounded as it is in the quality of the mathematics and the mathematical integrity of teachers, is singularly well placed to seize the opportunity. ■

Herb Clemens, Professor of Mathematics at the Ohio State University, is a former Director of PCMI and Member (1968–70, 2001–02) in the School of Mathematics.

Einstein Legacy Society News

The Einstein Legacy Society notes with sadness the passing last December of its founding co-chair, Charles L. Jaffin. Charlie led the Einstein Legacy Society, along with co-chairs Rosanna Jaffin and Martin Chooljian, since its inception in 1996. In addition to these leadership roles, the Jaffins have a long-standing affiliation with the Institute, dating to the 1950s when Rosanna worked as a secretary for J. Robert Oppenheimer. Charlie and Rosanna have been generous supporters of the Friends of the Institute for several decades, with their annual giving at the Founders' Circle level contributing to the support of a Member. A portion of their annual gift has long been designated to support the IAS/Park City Mathematics Institute (see article, above), as well as mathematics researchers and students at the post-secondary level. Charlie's unwavering leadership and dedication to the Institute, as well as his friendship and support, will be greatly missed.

Recent Planned Gifts: The Institute has received several planned gifts that have been counted toward the $200 million Campaign for the Institute (see article, page 3), including a share of a Charitable Remainder Trust established by Trustee Emeritus Frank Taplin in 1976. Frank and his wife Margaret (Peggy) were active supporters of the Institute, and were instrumental in the preservation in 1997 of 589 acres of Institute woods, wetland, and farmland now known as the Institute Woods. Though Frank died in 2003, Peggy remained a Friend of the Institute until her death last fall. The Institute also received a recent bequest from the estate of Donald M. Wilson, a longtime Friend and valued member of the Friends Executive Committee who served for seventeen years from its inception in 1991. Other irrevocable planned gifts include the designation of the Institute as a recipient of annuity payments from a Charitable Lead Trust established by Arthur and Janet Eschenlauer, also Friends; a Charitable Gift Annuity established by Michael Gehret, Associate Director of the Institute, and his wife Lor; and a contribution to the School of Natural Sciences endowment fund made by Scott Tremaine, Professor in the School, and his wife Marilyn.

Bequest Intentions: Several donors have recently named the Institute for Advanced Study as a beneficiary in their estate plans, in recognition of the Institute's role in the world and in their lives. These intended gifts represent the donors' current plans and can be modified to accommodate changing circumstances. Those who notify the Institute of their intentions are recognized as members of the Einstein Legacy Society. We are pleased to welcome:

Betty W. (Tina) Greenberg, Friend of the Institute for Advanced Study and former Chair of its Executive Committee

Bruce McKellar, former Member (1966–68, 1999) in the School of Natural Sciences, and his wife Loris

Albert Nijenhuis, former Member (1953–55, 1961–62) in the School of Mathematics

Daniel Saracino, former Member (1986) in the School of Mathematics ■

Planned gifts play a vital role in ensuring the Institute's financial independence and standing as one of the world's leading centers for theoretical research and intellectual inquiry. Planned gifts can be large or small, and many can be structured to benefit the donor, as well as the Institute. Please contact Catie Newcombe at (609) 951-4542 or at cnewcombe@ias.edu if you would like to discuss planned giving options.

Princeton Regional Planning Board Unanimously Approves Faculty Housing Plans

On March 1, the Institute for Advanced Study's plans for Faculty housing received unanimous approval (10–0) from the Regional Planning Board of Princeton. The plan, as approved, allows the building of eight townhouse units and seven single-family homes on a seven-acre parcel of private land adjacent to the Institute's campus and provides for a 200-foot buffer zone alongside the Princeton Battlefield State Park, with an additional ten acres adjacent to the Park scheduled to be conserved permanently as open space. In casting its vote, the Board agreed with the Township planning and engineering staff that the Institute had met all requirements to proceed with its plans.

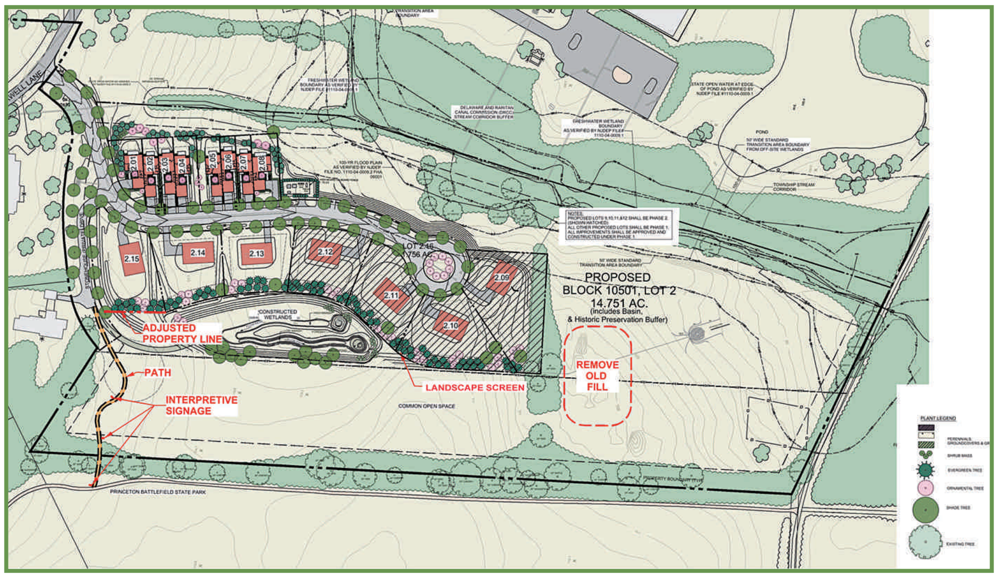


Illustration of the Institute's site plan for Faculty housing as it was approved at the March 1 Princeton Regional Planning Board meeting. The red type indicates the adjustments recommended by Professors McPherson and Hackett Fischer.

INSTITUTE FOR ADVANCED STUDY

"We are immensely pleased to receive unanimous approval for our Faculty housing plans from the Regional Planning Board of Princeton," said Peter Goddard, Director of the Institute. "This plan not only enables us to maintain the essential residential character of our community of scholars, but it will also enhance the Princeton Battlefield Park, which the Institute helped to create and expand. We plan to work with others to promote the improvement of the interpretative materials in the Park so that visitors might gain a greater understanding and appreciation of the Battle of Princeton. We look forward to partnering with local, state, and regional bodies to this end."

The plan was approved with amendments that resulted from discussions between the Institute and leading historians James McPherson, George Henry Davis 1886 Professor Emeritus of American History at Princeton University, and David Hackett Fischer, University Professor and Earl Warren Professor of History at Brandeis University. McPherson and Hackett Fischer jointly recommended several adjustments to the Institute's plan to meet the residential needs of the Institute while protecting the Princeton Battlefield Park. They include: moving a screen of trees from the western edge of the 200-foot buffer zone to the edge of the lots of the single-family homes on the eastern side of the zone; adjusting one of the property lines on the northwest portion of the site; removing the compost area on the undeveloped end of the southern field and regrading the land; and adding a path and interpretive signage at the northern end of the site. In line with the Institute's commitment to preservation (the Institute has conserved in perpetuity more than 78 percent of its land holdings as the Institute Woods and farmland), archeological protocol will ensure the proper detection, documentation, and deposit of any remaining artifacts before and during the building of the residences, which are essential to the Institute's future as a residential community of scholars. More information about the Institute's Faculty housing plans and the preservation and historical contexts is available on the Institute's website. ■

CHAKRABARTY APPOINTMENT *(Continued from page 1)*

Chakrabarty has reshaped the field of history through his analyses of political, economic, and social formations and spurred reformulations of core concepts in the social sciences. "The global impact of Chakrabarty's scholarship, his personal commitment to intellectual community, and the far-reaching range of his research network prepare him well for the thoughtful, energizing leadership expected of Faculty at the IAS," noted Danielle Allen, UPS Foundation Professor in the School of Social Science. "We are delighted that he will join us."

Initially trained in physics, Chakrabarty earned a B.Sc. from the University of Calcutta in 1969 and a Postgraduate Diploma in Management (an MBA equivalent) from the Indian Institute of Management Calcutta in 1971. During his business school years, Chakrabarty became interested in India's economic and social development, and in particular the challenges faced by the country, as seen through the lens of India's colonial past and postcolonial present. He obtained his Ph.D. in History from the Australian National University in 1984, working under D. A. Low, the noted historian of modern South Asia and Africa. Chakrabarty's graduate research on Bengal's working class at the turn of the nineteenth century served as the basis for his first book, *Rethinking Working-Class History: Bengal 1890–1940* (1989). Inspired by E. P. Thompson's *The Making of the English Working Class* (1963), Chakrabarty confronted the question of whether European models could be applied to the history of the Indian working classes and challenged whether the category of "the working class" was too deeply tied to its European origins to transfer effectively to any part of the world, wherever a recognizable labor force exists. The book introduced new methodological innovations and led to the development of a historiographic method that closely scrutinized the relations among historically specific social formations, the conceptual tools of social analysis arising from them, and the relative transferability of those tools to different contexts.

In Chakrabarty's second book, *Provincializing Europe: Postcolonial Thought and Historical Difference* (2000; second edition, 2007), he systematically investigated how and in what sense European ideas that were labeled "universal" were drawn from very specific intellectual traditions and historical contexts that left their marks on these ideas even when they could claim a degree of universal validity. In his examination of historical thinking and postcolonial perspectives, Chakrabarty used the context of the middle-class Bengali culture in which he grew up to explain how the "heterotemporal horizons" of locality anchor the structures of sentiment, emotion, and practices that inform the terms used for universalizing purposes. In employing new tools of social analysis, Chakrabarty's goal was to understand "how universalistic thought was always and already modified by particular histories, whether or not we could excavate such pasts fully," and he advocated that such an approach was necessary to compare different political and social formations.

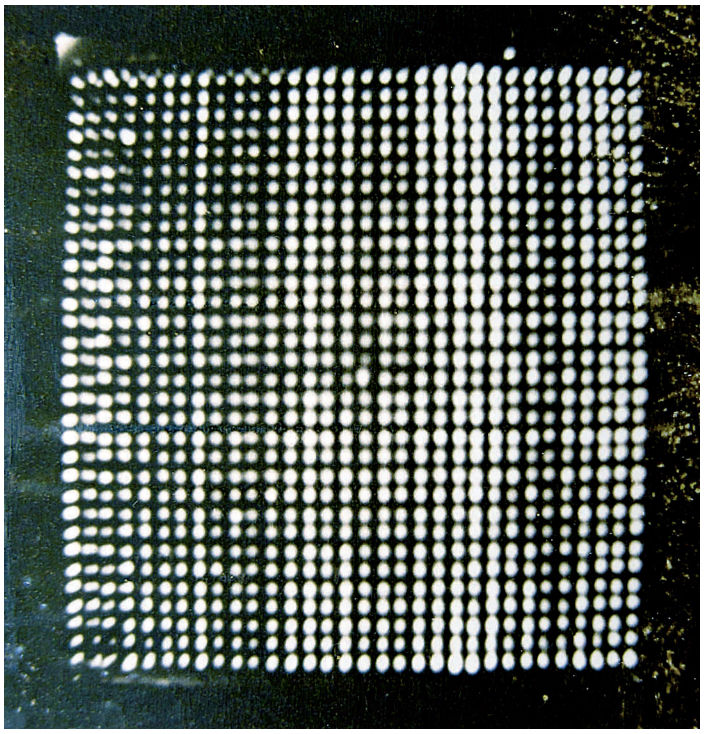
Chakrabarty is among the founders of the highly influential field of inquiry known as subaltern studies, which draws on the idea that peasants, once ridiculed by Marx and other social thinkers for their "rural idiocy," may have a positive political role to play in effecting social transformation in postcolonial countries. India, in particular, provided fertile ground for examination into these concepts; when its constitution was enacted in 1950, it granted the right to vote to all adult Indians, the majority of whom were rural and nonliterate, effectively turning peasants into democratic citizens overnight. As part of a collective of scholars that has published the series *Subaltern Studies*, Chakrabarty and his collaborators have examined India's peasant-democracy and explored several interrelated topics: the political agency of subaltern classes, the historical genealogies of the nation-state as a form of political organization, and the deep complicity of the discipline of history with the phenomenon of nationalism. This work was part of the wave of democratic ideas that swept the liberal-democratic world in the wake of 1968 and after the fall of the Berlin Wall.

Chakrabarty's current work is centered on a project on anthropogenic climate change and its implications for historical and political thinking; its launching point was his influential essay, "The Climate of History: Four Theses," published in *Critical Inquiry* in 2009. He is also pursuing a major project on the history of "historical truth" with a focus on the Indian historian Sir Jadunath Sarkar (1870–1958). In a forthcoming book, "The Calling of History," Chakrabarty explains how, before history became a profession in India in the 1930s, historians questioned and debated ideas and practices such as source criticism, research in history, the transformation of old papers into "records," the institution of the archive, the idea of historical truth, and related questions. Chakrabarty posits that while disciplines have a global life at the level of journals and publications, they also have plural and heterogeneous social lives through the histories of the institutions in which they operate and their different national contexts. Additionally, Chakrabarty is developing two other long-term projects: one on democracy and political thought in South Asia and the other on a cultural history of Muslim-Bengali nationalism.

Chakrabarty has lectured extensively throughout the world, and his books and articles have been or are being translated into many languages, including Arabic, French, Spanish, Italian, Korean, German, Chinese, Turkish, Polish, Portuguese, and Hungarian. He serves as a coeditor of *Critical Inquiry*, is a founding editor of *Postcolonial Studies*, and is on the editorial boards of leading scholarly publications in the United States, India, Europe, and Australia. Chakrabarty is a Fellow of the American Academy of Arts and Sciences and is an Honorary Fellow of the Australian Academy of the Humanities. In 2007, he received the Eminent Scholar Award of the Global Development Section of the International Studies Association. He was awarded a D.Lit. (*Honoris Causa*) from the University of London (2010) and an honorary doctorate from the University of Antwerp (2011). In 2011, his alma mater, the Indian Institute of Management Calcutta, honored him with a Distinguished Alumnus Award on the fiftieth anniversary of the Institute. Chakrabarty is currently Chair of the Provostial Ad Hoc Faculty Committee on the Proposed University Center in India, and he is a member of the Board of Advisors on non-Western Art and Museums of the Humboldt Forum in Germany. ■

The Institute Letter

Spring 2012



INSTITUTE FOR ADVANCED STUDY

Space and Time

In this 1953 diagnostic photograph from the maintenance logs of the IAS Electronic Computer Project (ECP), a 32-by-32 array of charged spots—serving as working memory, not display—is visible on the face of a Williams cathode-ray memory tube. Starting in late 1945, John von Neumann, Professor in the School of Mathematics, and a group of engineers worked at the Institute to design, build, and program an electronic digital computer—the physical realization of Alan Turing's Universal Machine, theoretically conceived in 1936. As George Dyson writes in the following pages, the stored-program computer broke the distinction between numbers that *mean* things and numbers that *do* things.

The properties of a digital universe, as modeled by Turing and implemented by von Neumann, are based on the translation of information across space and time. In his book, *Turing's Cathedral: Origins of the Digital Universe* (Pantheon, 2012), Dyson explains:

> A digital universe—whether 5 kilobytes or the entire Internet—consists of two species of bits: differences in space, and differences in time. Digital computers translate between these two forms of information—structure and sequence—according to definite rules. Bits that are embodied as structure (varying in space, invariant across time) we perceive as memory, and bits that are embodied in sequence (varying in time, invariant across space) we perceive as code. Gates are the intersections where bits span both worlds at the moments of transition from one instant to the next.

Perceptions of space and time are explored in a number of articles included in this issue—from time-domain astronomy, which tells us that the particular space we occupy in the Universe is rather strange, to Dipesh Chakrabarty's ideas about the transferability of political, economic, and social formations across eras and localities (page 1), to the idea of wartime as a gap in history when time itself is suspended (page 4), to the tension between emergent and mythic time embedded in a fifteenth-century painting (page 6).

IAS The Institute Letter

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