AMERICAN ACADEMY OF ARTS & SCIENCES

Bulletin

WINTER 2008

VOL. LXI, NO. 2

Page 1

Academy Inducts 227th Class of Members

Page 29

Energy and Climate Change

Richard A. Meserve, Rosina M. Bierbaum, William K. Reilly, and Richard L. Revesz

Page 42

Nuclear Power without Nuclear Proliferation?

Scott Sagan, William J. Perry, Alexei Arbatov, and Thomas Isaacs

Page 53

The World's Energy Problem and What We Can Do About It

Steven Chu

INSIDE:

Contents

News

Academy Meetings

AMERICAN ACADEMY
OF ARTS & SCIENCES

Calendar of Events

Wednesday, February 13, 2008

Stated Meeting – Cambridge

Science, Policy, and the Media

Speaker: Donald Kennedy, *Science* Magazine and Stanford University

Location: House of the Academy

Time: 6:00 p.m.

Saturday, February 23, 2008

Stated Meeting – California

The Art and Science of Conservation

Speakers: James Wood, J. Paul Getty Trust; **Robert Campbell,** *The Boston Globe*; **Jorge Silvetti,** Machado and Silvetti Associates; **Jerry Podany,** J. Paul Getty Museum

Location: The Getty Villa

Time: 5:00 p.m.

Monday, March 3, 2008

Film Screening and Discussion – Cambridge

Constantine's Sword

Speaker: James Carroll, Boston, MA

Location: House of the Academy

Time: 5:30 p.m.

Thursday, March 13, 2008

Stated Meeting – Cambridge

The Research Library in the Information Age

Speaker: Robert Darnton, Harvard University

Location: House of the Academy

Time: 6:00 p.m.

Wednesday, April 9, 2008

Stated Meeting – Cambridge

Science Results from the Mars Exploration Rover Mission

Speaker: Steven W. Squyres, Cornell University and Mars Exploration Rover Project

Location: House of the Academy

Time: 6:00 p.m.

Wednesday, May 14, 2008

Stated Meeting – Cambridge

Speaker: To be announced

Location: House of the Academy

Time: 6:00 p.m.

For information and reservations, contact the Events Office (phone: 617-576-5032; email: mevents@amacad.org).

Academy News

Academy Inducts 227th Class of Members

From Jessye Norman's extemporaneous rendition of "American the Beautiful" to Rodney Brooks's vision of robots capable of advancing understanding of human intelligence, the Academy's 227th Induction Ceremony was a celebration of the extraordinary achievements of its newly elected Fellows and Foreign Honorary Members. On Saturday, October 6, 2007, 579 Fellows and guests attended the event. Coming from across the country and as far away as Israel, the participants included physical and biological scientists, humanists and social scientists, writers, performers, filmmakers, architects, philanthropists, and government and corporate leaders (see pages 62 – 79 for descriptors of the new members).

In his opening greeting, President of the Academy **Emilio Bizzi** remarked, "By electing you to membership, the Academy honors you, but you, in turn, honor the Academy by strengthening our mission to engage in critical thinking that will lead to constructive action on issues that concern all of us." Recalling the Academy's historic tradition, Chief Executive Officer **Leslie C. Berlowitz** noted that at a time when our founding members were creating the Academy, they were also waging a war for independence and establishing the institutions of the new nation. "The Scholar-Patriots who built the Academy were busy people too," she said. "They were nineteenth-century multitaskers who found time to advance their own professional careers, while engaging in scholarship and statesmanship for the public good. We are indebted to them for their service to the nation and to the Academy, and we look to you to build on their legacy."

The speakers at this year's ceremony considered many challenges confronting our society, focusing on the need to bring greater knowledge, deeper understanding, and a broader perspective to long-standing as well as emerging issues. MIT robotics professor and iRobot Corporation's cofounder **Rodney Brooks** set the development of humanoid robots in the context of man-machine relationships in history, while Princeton University molecular biologist **Bonnie Bassler** considered the need for new antimicrobial therapies at a time when bacterial infections, once thought to be treatable, are emerging in new, virulent forms.

University of California, Berkeley's law school dean **Christopher F. Edley, Jr.** discussed the future of the civil rights movement, urging those involved to combine their "secular, technocratic strategies with a recommitment to the discourse of values and even to the tactics of spiritual engagement." By exploring the roles of interactions and relationships, President of the University of Chicago **Robert Zimmer** demonstrated how the structure of mathematics, music, and university leadership – seemingly disparate subjects – can be more effectively understood.

Prize-winning architect **Billie Tsien** observed that in an era of eye-catching, trophy buildings, we need to look inside, to examine the

President Emilio Bizzi '80 (MIT) and Secretary Jerrold Meinwald '70 (Cornell University) congratulating new member Lily Jan '07 (University of California, San Francisco). Chair of the Academy Trust and Vice President Louis Cabot '58 (Cabot-Wellington, LLC) is in the background.

"interior life that defines both the building and the human being . . . to appreciate what touches people, what comforts them, what makes memories." An advocate of arts education in America's schools, opera and concert artist **Jessye Norman** stated that "art makes each of us whole by insisting that we use all of our senses, our heads, and our hearts; that we express with our voices, our hands, our bodies, as well as our minds." (See pages 7 – 14 for the full text of the speakers' remarks.)

The afternoon Induction Ceremony followed a morning orientation session at which leaders of Academy studies and research projects described their work, examining such topics as the well-being of the humanities; academic freedom; the future of the media in America; the resurgence of nuclear power worldwide; Internet safety and security; the independence of the judiciary; and the evolving role of science, engineering, and technology in today's world. (The orientation talks appear on pages 15 – 24.) Throughout their presentations, the speakers emphasized that the Academy seeks to assess all sides of difficult problems, to conduct long-term analyses of American and international policy choices, and to further scholarship as the basis for thoughtful action. As Academy Librarian **Robert C. Post** put it, "The Academy is multidisciplinary and it is nonpartisan. It can serve as an honest broker for matters of intense and intractable public controversy." ■

Andrew W. Mellon Foundation Awards Academy $250,000 Grant

The Andrew W. Mellon Foundation has awarded the Academy a $250,000 grant to catalog, conserve, and improve access to the Academy's earliest and most historically significant records.

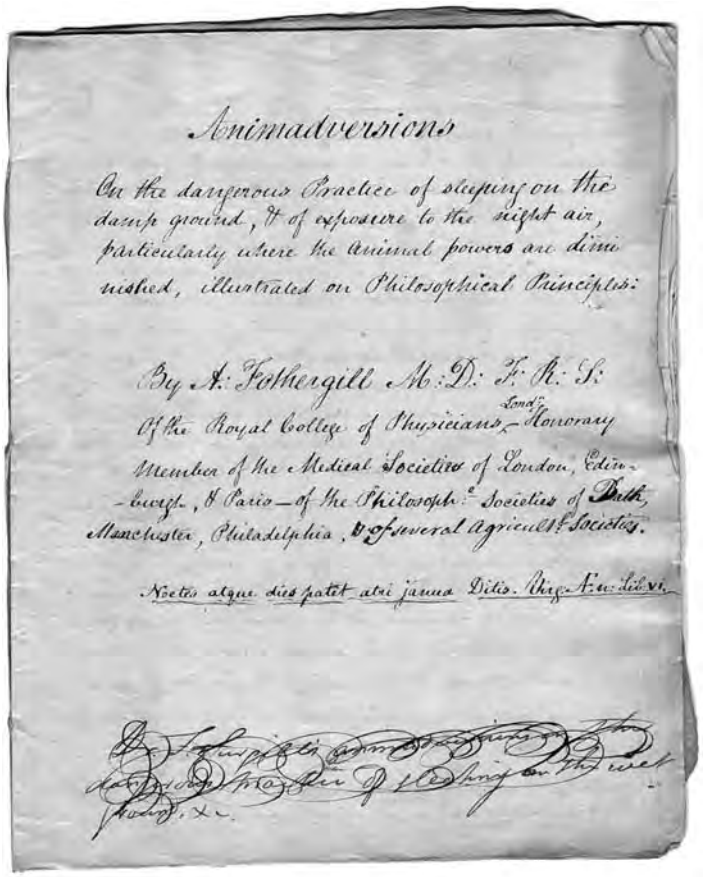
Last year, thanks to the generous support of an anonymous donor, the Academy completed construction of a modern, state-of-the-art archive facility – including compact storage units, appropriate shelving, and independent climate control – at its headquarters in Cambridge. This new grant will allow the Academy to move into the next phase of its archive project: to organize, catalog, and preserve the Academy's records and to provide scholars with access to some of the institution's earliest documents.

"The Academy's records provide insight into the growth and development of America's intellectual traditions, and document what our nation's scholars and leaders were discussing and thinking during critical historical moments. These valuable resources have never been available to researchers," said Leslie Berlowitz, CEO of the Academy. "The Academy now has a wonderful opportunity to provide scholars access to these collections and to understand better its own rich history as well."

Among the Academy's holdings are 35 volumes of Letter Books, containing communications from such early Fellows as George Washington, Thomas Jefferson, and Alexander Hamilton, as well as correspondence with other learned societies in the late eighteenth and early nineteenth centuries; complete runs of all Academy serial publications, including the *Memoirs*, *Proceedings*, and *Dædalus*; 10 volumes of manuscript Minute Books, which document Academy meetings and other governance activities from 1780 to 1944; manuscripts of communications submitted by members and others for possible publication; and reports from both special and standing committees, which detail membership and program activities since the Academy's founding in 1780.

The Mellon award to the Academy will support archival assistants to help with the retrieval, review, and processing of all off-site holdings, as well as allow the Academy to purchase and install specialized records management and cataloging software; select the first series of historical documents and publications for processing; create finding aids and collection-level descriptions for these series; consult with outside technical and conservation experts; and design an archives section of the Academy website, among other things.

An Archives Advisory Committee, overseeing all aspects of the Archives Initiative, includes Fellows Joyce Appleby (University of California, Los Angeles), Bernard Bailyn (Harvard University), Leslie C. Berlowitz (American Academy), Academy Librarian Robert C. Post (Yale Law School), and Patricia Meyer Spacks (University of Virginia), as well as Ellen Dunlap (American Antiquarian Society), Brenda Lawson (Massachusetts Historical Society), Bernard Margolis (Boston Public Library), and Megan Sniffin-Marinoff (Harvard University Archives). ■


Animadversions

On the dangerous Practice of sleeping on the damp ground, & of exposure to the night air, particularly where the Animal powers are diminished, illustrated on Philosophical Principles:

By A. Fothergill M:D: F: R: S:
Lond.
Of the Royal College of Physicians — Honorary
Member of the Medical Societies of London, Edinburgh, & Paris — of the Philosophic Societies of Bath,
Manchester, Philadelphia, & of several Agricult.l Societies.

Noctis algue dies patet atri janua Ditis. Virg. Æn. Lib. VI.

In the Academy's archives: title page of Anthony Fothergill's "Animadversions on the Dangerous Practice of Sleeping on the Damp Ground and of Exposure to the Night Air, Particularly Where the Animal Powers Are Diminished," undated.

Anthony Fothergill (1732–1813) was an Edinburgh-educated physician and natural historian, who submitted several essays to the Academy for discussion and publication.

Stephen D. Bechtel, Jr. Auditorium Dedicated

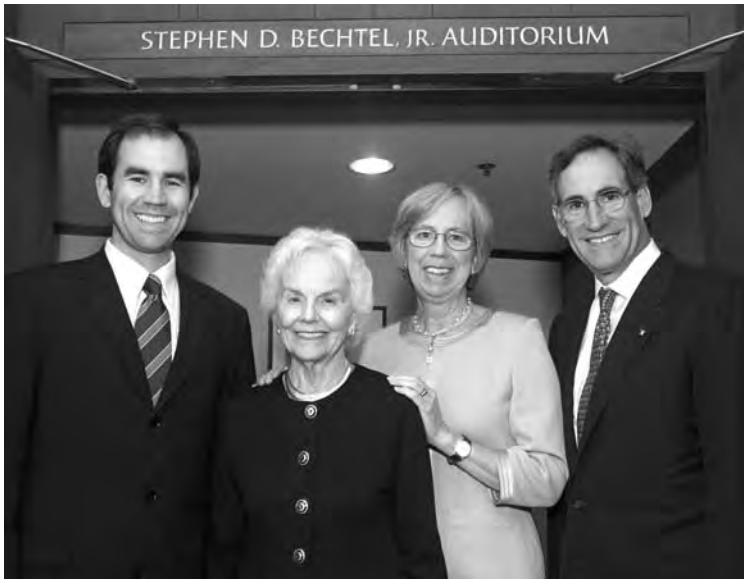
Stephen D. Bechtel, Jr.

Officers of the Academy and members of the Council and Trust dedicated the Stephen D. Bechtel, Jr. Auditorium in the Academy's Cambridge headquarters at a ceremony on Saturday, October 6, 2007, on Induction weekend.

Chair of the Academy Trust and Vice President Louis W. Cabot paid tribute to the generosity of Fellow Stephen D. Bechtel, Jr. and his foundation to the Academy. "For over a decade, both Steve and the S. D. Bechtel, Jr. Foundation have made a series of generous gifts and grants to help with strategic planning, to advance our projects and studies, and to refurbish our national headquarters. Steve has a special understanding of the way this institution, which brings together people from every field and discipline, serves America and the world."

Members of the Bechtel family attending the dedication included Mrs. Bechtel, her grandson Eric Dachs, son-in-law Alan Dachs, and daughter Lauren Dachs, President of the S. D. Bechtel, Jr. Foundation. In her remarks, Mrs. Dachs noted, "On behalf of my father, we are delighted to be here for the dedication and to celebrate the excellent work of the Academy. It has been an honor to partner with the Academy and we look forward to continuing our support."

Stephen Bechtel is Chairman (retired) and a Director of Bechtel Group, Inc., and Chairman of the S. D. Bechtel, Jr. Foundation. He served as a director on the boards of several major corporations, including General Motors and IBM. Presidents Johnson, Nixon, and Ford each appointed him to presidential committees and commissions. The recipient of numerous industry, academic, and professional society awards, Mr. Bechtel served as chairman of The Business Council, The Conference Board, Inc., and the National Academy of Engineering. He was Vice Chairman of the California Council for Science and Technology Task Force in 2006, advising the Governor of California on increasing the state's talent pool by improving K-12 science and mathematics education. Elected to the American Academy in 1990, he has served on membership committees and provided major support for a project initiative in science, engineering, and technology as well as for capital improvements to the Academy's headquarters. The American Academy is grateful for his continuing interest and his extraordinary support for projects and programs. ■



Eric Dachs, Elizabeth Bechtel, Lauren Dachs, and Alan Dachs

Induction 2007

New members Jessye Norman (New York, NY) and Jacques d'Amboise (National Dance Institute)

Loren Ghiglione '04 (Northwestern University) and David Levi '07 (Duke University)

Gerald Rosenfeld '04 (Rothschild North America and New York University), Richard Revesz '07 (New York University), and Kenneth Wallach '07 (Central National-Gottesman, Inc.)

Judith Shapiro '07 (Barnard College) and Nell Irvin Painter '07 (Princeton University)

Helen Piwnica-Worms '07 (Washington University in St. Louis) and Robert Lamb '07 (Northwestern University)

Mary Lake Polan and Frank Bennack '07 (Hearst Corporation)

William Reilly '07 (TPG Capital/Aqua International Partners LP)

Induction 2007

Tod Williams '07 (Tod Williams Billie Tsien Architects, LLP), Billie Tsien '07 (Tod Williams Billie Tsien Architects, LLP), and Robert A. M. Stern '07 (Yale University School of Architecture and Robert A. M. Stern Architects)

Gail Mandel '07 (Oregon Health and Science University) and Josh Mandel-Brehm

Peter Li '07 (University of California, Irvine)

Rosalie Abella '07 (Supreme Court of Canada) and Robert C. Post '93 (Yale Law School)

Induction Ceremony

Challenges Facing a Global Society

On October 6, 2007, the American Academy of Arts and Sciences inducted its 227th class of Fellows and Foreign Honorary Members at a ceremony held in Cambridge, Massachusetts. Robotics professor **Rodney Brooks**, molecular biologist **Bonnie Bassler**, civil rights champion and law dean **Christopher F. Edley, Jr.**, architect **Billie Tsien**, mathematician and university president **Robert J. Zimmer**, and opera and concert artist **Jessye Norman** addressed the audience. Their remarks appear below.

Rodney Brooks

Panasonic Professor of Robotics, Massachusetts Institute of Technology; Chief Technology Officer, iRobot Corporation

This Academy has long been concerned both with science and technology and with human society and human values. Over the years, we have seen conflicts and confusions arise across these arenas of human endeavor.

I want to talk briefly about a new area where our human views of the nature of the universe will be more and more challenged by developments in science and technology. I want to talk about our relationships with machines and some issues we will face.

Mankind has often had rocky relationships with new sorts of machines. The machines of the industrial revolution brought affordable goods to all, but the cost was enslavement of many to inhuman working conditions. Computer networks have brought us instantaneous access to much of the world's knowledge and also to family anywhere, anytime – but they have also brought us the tyranny of email and spam.

But now new sorts of machines are coming into existence – ones with both physical extent and mental intent. These "robots" are unlike machines that we as humans have encountered in the past.

Some of the robots that are being built today have ongoing intents and desires. Simple at the moment, certainly in those that are commercially deployed, but somewhat less simple in the ones built in laboratories. These robots perceive the world through multiple sensors. They learn skills and they act in the world based on the current context: which people are present and what those people are doing. The robots carry on with their intents and desires, advancing their own causes when opportunities present themselves. In this, they are different from all the machines we have built in history. These robots have some aspects of inner lives.

The beingness of our near-term machines will be a rich stimulant for arguments about what it is that we are, and what our relationships to our new intellectual brethren should be.

Many of you might say, "But such robots can only do what they are programmed to do." That is a clear example of the conflict between science and technology, on the one hand, and our human views of ourselves, on the other. I remind you that, at the very least, the implicit assumption of modern science is that you can only do what your biomolecules program you to do. Nowhere will you find in a course on molecular biology an invocation of the soul to describe how one molecule interacts with another. And nowhere in a course on neuroscience will you find free will invoked to explain how much neurotransmitter is produced at a synapse. Free will and soul are in modern science emergent properties of lawful lower-level physics and chemistry.

Likewise, intelligent machines can only do what the physics of their transistors and stored program bits allow them to do. But let us not confuse ourselves that their behavior is any less spontaneous than that of you or me operating under the constraints of our molecular underpinnings.

How will we treat these machines, and how will we interact with them?

Some of these questions will be answered through the marketplace. North American and European companies seem to be focused on robots that do useful work for people. Japanese companies, on the other hand, seem to be betting more on robots as companions, as friends for the elderly.

But however the commercial markets play out, there will be real challenges for us as social scientists, lawgivers, and humanists.

There will be legal questions of who is at fault when a machine, which has aspirations and intent, causes damage. Is there ultimately a human at fault? Is it the designer, the owner, or the manufacturer of the machine? Or will machines themselves someday be held accountable?

More immediately, do we want our machines to be given independent targeting authority in wars and permission to decide what or who to shoot at without a person in the control loop? Or will humankind draw a line in the sand and say that we will not go there – we

will not let robots make those decisions, just as we use the Geneva Protocol to outlaw biological weapons.

The beingness of our near-term machines will be a rich stimulant for arguments about what it is that we are, and what our relationships to our new intellectual brethren should be. This debate will probably continue for a century or more to come.

But there are shorter-term issues that will arise when we couple the silicon and steel of our robots with our own flesh. There are already more than fifty thousand people worldwide with cochlear implants that let them hear. They have computers inside their heads with wires running to their cochleas. These people have direct electrical connections between a computer and some of their neurons.

Such techniques are accelerating. We have seen monkeys with neural implants able to control robot arms by thinking. Early experiments have given quadriplegic humans a little control over their environments by having them "just think" in order to make a robot arm reach or grasp.

Once we had plastic surgery, people started to use it not just for medical reconstruction, but for vanity self-modification. Some people will want to use silicon implants to augment themselves. In my own case, if I could have a WiFi implant where I could "think" Google queries and get the answer to pop into my consciousness, I would have that surgery in a second.

Sporting-event organizers spend considerable energy on ensuring that competitors are not enhanced. We have long seen this with drugs and blood doping. But just in the last few weeks we have seen amputees who are banned from the regular Olympics on the grounds that artificial legs give them too much of an advantage.

When will this Academy be faced with the issue of electing someone, or not, whose accomplishments have been clearly enabled by a silicon augmentation?

In closing, I want to assure you that this particular new member is both very honored to be here and is neither enhanced nor a robot. Yet.

Bonnie L. Bassler

Squibb Professor in Molecular Biology, Princeton University; Investigator, Howard Hughes Medical Institute

My first goal for this short talk is to convince you that bacteria can talk to each other. My second goal is to convince you that they are multilingual. But before I do that, I want to emphasize that knowing about the conversation bacteria are having and knowing how to enter it are critical. Furthermore, in this discussion there is an important place for academic science, which is being propelled almost exclusively by people in their twenties and thirties.

We have an acute need for new antimicrobial therapies. With the advent of antibiotics in World War II, the bacterial problem was thought to be solved. Increasingly, however, bacterial infections that were once easily treatable are proving resistant to all available antibiotics. We are watching new infectious diseases emerge and spread with alarming speed. In the underdeveloped world, each year people die by the thousands from untreated microbial diseases. Compounding this problem is a substantial decrease in investment in antimicrobial research by large pharmaceutical companies, because of the extended time that it takes to bring new drugs to the market, the increasing costs of clinical trials, and complicated regulatory and legal environments. The sad fact is that boutique drugs – those for hair loss, mood control, cholesterol control – are easier to develop, and they make a lot more money.

So this picture seems all gloom and doom. How then can we bring new ideas and new compounds from the laboratory to the clinic to counteract the rapidly emerging bacterial threat? I would argue that we do it in an academic setting that encourages the development of young scientists who are simply curious about how the natural world works, but who are not yet concerned with, or are unaware of, the economic and political forces that underpin their findings. It is important to note that the young people who pursue science today must somehow first successfully navigate a culture that does not understand or value science, that fears scientific progress and associates it with evil, and that gives intelligent design equal or more merit than it gives to Darwin's theory of evolution. Thus, young people that enter science today are already extraordinary creatures in their own right. They are already pioneers. By the time they get to college, they are already engaged in fundamentally changing our perception of the natural world.

What we now understand is that bacteria do not act as individuals. They talk to each other, and the language they use is chemical: it is made up of molecules.

With those ideas in mind, I want to tell you a little bit about how bacteria talk to each other, and about what the young men and women in my group are doing, first, to understand the personalities of bacteria and their languages, and then to interfere with those conversations in order to develop new antibiotics.

We have known about bacteria for over three hundred years. They are supposedly the simplest organisms on earth: they are single cells and have one piece of DNA. They have always been considered to be asocial, reclusive loners: supposedly they eat, they divide in half, and the offspring do their own thing without regard to their siblings. So how then do bacteria accomplish all the terrible things

that we read about in the newspaper, and also all the miraculous things that are beneficial for us? Because they are so small, if bacteria only acted as individuals they could not possibly have an impact on their environment.

What we now understand is that bacteria do not act as individuals. They talk to each other, and the language they use is chemical: it is made up of molecules. Some of the molecules are used exclusively for communication within a particular species. Species-specific molecules enable private or secret conversations. Other molecules are used for interspecies communication. These nonspecific molecules are more like trade languages, or the equivalent of bacterial Esperanto, and they allow bacteria to talk freely to all kinds of other bacteria. By perceiving the accumulation of blends of these different molecules, bacteria can distinguish self from other. We argue that the ability of bacterial cells to distinguish self from other was one of the first steps in the development of higher organisms and was critical to the evolution of the kinds of functions carried out by cells in the human body.

The other thing that chemical communication lets bacteria do is to count. Bacteria make and release these communication molecules into the environment. The more bacteria there are, the more of these molecules there are. When the bacteria perceive that a particular amount of a molecule has accumulated in the vicinity, all the cells respond to the molecule by acting in unison. Specifically, the bacteria change their gene expression, or their behavior, in synchrony. In this way, bacteria act like enormous multicellular organisms, carrying out tasks and reaping benefits that they could never accomplish if they simply acted as individuals. We call this phenomenon "quorum sensing." The bacteria vote, they count the vote, and then the group goes along with the vote. This concept of bacterial quorum sensing lies in stark contrast to our three-hundred-year-old notion that bacteria act only as loners. In fact, we now understand that bacteria have a rich chemical vocabulary and they act in enormous groups. We also now understand that this is why pathogenic bacteria are so successful at making us sick, and also why commensal bacteria are so successful at keeping us healthy.

Now that the students in the lab have deciphered a few of the chemical words in the bacterial lexicon, we want to enter into the conversation in order to interfere with it. The idea we are investigating now is whether we can make the bacteria deaf or make them mute. If the bacteria cannot talk or listen to their neighbors, they cannot initiate group behaviors like virulence. The hope is that we can develop new antibiotics that would not kill bacteria, but would rather modify their behavior and render them harmless. The hope of these anti-quorum sensing therapies is that, since they do not actually kill bacteria, they would not strongly select for resistance the way traditional antibiotics do. Conversely, we are also exploring the idea of developing pro-quorum sensing strategies. Bacteria have a bad reputation, but in fact, we use bacteria to make all kinds of needed products. If we could make quorum sensing better in beneficial bacteria, we could use them to acquire additional natural products for medical, commercial, and industrial purposes.

It turns out that the clever notions of manipulating quorum sensing are not my group's original ideas. Bacteria have had a billion-year head start in that arena, and they have already invented pro- and anti-quorum sensing tactics. We know that bacteria eat each other's words; they block free speech in chemical expression; they eavesdrop; they cheat; they free ride; and they engage in all kinds of dirty chemical and biological warfare tricks. We would simply like to copy those strategies and apply them in clinical and industrial settings. Next, we would like to explore if the bacterial hosts – namely, humans – are tuned into this bacterial conversation.

Christopher F. Edley, Jr.

Dean and William Orrick, Jr. Professor of Law, Boalt Hall School of Law, University of California, Berkeley

Because you and I would prefer to hear from another of the inductees, I have been asking myself, "What would Al Gore say?" My subject today is the future of the civil rights movement, which I invented.

In surveying the modern American struggle for racial justice, I consider the murder of Martin Luther King, Jr., forty years ago this coming April 4, a reasonable place to mark the shift in leadership from clergymen to lawyers and policy engineers. These new leaders largely abandoned the language of values and their spiritual underpinnings in favor of constitutional litigation, the analysis of dual labor markets, the design of preschool interventions, and such. Faith leaders working in the cause of justice continued to use their basement meeting rooms, their mailing lists, and their ability to draw a local television crew, but even these leaders usually put aside their theology to secularize their labors.

And thus beacons that had shone down through millennia, beacons lighted by Moses and Mohammed and Maimonides, were effectively shuttered by a fog of footnotes and regression equations.

Surely this is peculiar inasmuch as the central challenge of defining and achieving racial justice concerns connecting communities and stoking compassion – matters of iden-

tity and values, matters which Americans, among the most worshipping of industrialized *Homo sapiens*, are far more likely to engage through the discourse of spirituality, if not religion, rather than through the stuff that I do.

Well, what is to be done? The social science evidence demonstrates that discrimination continues; it is widespread but often subtle. Cognitive scientists point toward unconscious forms of bias – ubiquitous, robust, and pernicious. Yet science alone cannot revitalize the antidiscrimination paradigm in law or in politics, because this is not about technocratic truths. It is about ethical chasms that can only be bridged with a moral and ethical agenda.

We must recognize that America is not immune from violent chaos based on our differences. Look at history. Look at the world. Look at human nature.

This, then, is the first clue to the future of civil rights: the movement must augment its secular, technocratic strategies with a recommitment to the discourse of values, and even to the tactics of spiritual engagement.

The second clue comes from a frank recognition that Bull Connor is long dead and that our contemporary polity is politically and ethically exhausted on race, having become impatient with the search for racial wrongdoers and quite conveniently oblivious to history. During this past generation, the courts have been a big part of this steady retreat, pausing occasionally with a decision one might call, "Not quite as bad as it might have been." I say retreat because this direction is a detour if one hopefully takes the Warren Court victories of yesteryear as the truer course for America's future. Many do not.

Meanwhile, the antidiscrimination paradigm must be augmented with another strategy, which I term "no-fault regulatory rights." Think of dream-crushing high school dropout rates, or brutal medical pain mismanagement in a hospital waiting room. Stated simply, we can construct policies in which some forceful financial or other intervention is triggered – not based on a factual predicate of discrimination, but instead on the mere existence of a racial disparity or inequity we deem unacceptable as a matter of policy.

The most prominent example of this today is the No Child Left Behind Act. Notwithstanding its many flaws, there is a central civil-rights virtue to the scheme: educators and administrators are held accountable for narrowing racial disparities in K-12 achievement, using an escalating series of interventions. The key is that the rewards and sanctions are triggered without first stopping to search for someone with racial animus dripping from his or her lips.

We regulate air pollutants, not to assign blameworthiness, but to alleviate an unacceptable public health risk. Similarly, we should engineer policy reforms and resource reallocations to alleviate the unacceptable risks of a nouveau Jim Crow and an America of tomorrow ripped asunder.

In that regard, and finally, I recall a conversation with President Bill Clinton in which he spoke of sitting in the Oval Office with leaders from nations in which thousands of people are murdered each month because of racial, tribal, and religious differences. Those leaders see in our America an inspiring demonstration that a diverse society can be secure and prosperous. But we must recognize that America is not immune from violent chaos based on our differences. Look at history. Look at the world. Look at human nature. Indeed, we do have some of that chaos now, but we could have much, much more.

Clinton believed this could be the nation's toughest challenge for the twenty-first century, because if we can deal with our racial and other differences, Americans can eventually handle everything else.

I have sketched a moral challenge and an engineering challenge. Sadly, I am not religious – just a democrat, small "d," and, worse, an academic. Not surprisingly, my prescription, my challenge to this Academy, is more research and deliberation. How do we change values and build community? How do we engineer around our racial exhaustion? These are extraordinarily difficult but researchable questions. As I often say, "Race is not rocket science." It is harder than rocket science. This is not a decade's race to the moon, but a centuries-old struggle over who we wish to be. A struggle unfinished. Let us continue.

Billie Tsien

Architect, Tod Williams Billie Tsien Architects, LLP

My husband, partner, and fellow inductee Tod Williams and I are teaching a studio course this semester at the architecture school at Yale. We gave each student a copy of Louis Kahn's lectures called *Essential Texts*. Kahn was the architect of a small number of powerful and iconic commissions, among them the Salk Institute in La Jolla, California; the Kimbell Art Museum in Fort Worth; and the National Assembly Building in Dhaka, Bangladesh.

Kahn taught for many years and became known for the sometimes puzzling, sometimes stunning aphorisms that he dropped like diamonds into his often murky and rather incantatory lectures and writing. He famously posed the question "What does a brick want to be?" because he was trying to understand the essential nature of this simple building material and how that might be expressed in architecture.

We gave the students an assignment to "excavate" the book. Since we are architects and work in the physical world, we meant this literally as well as figuratively. We wanted them to read the essays and to transform the books to express their understanding by actually cutting into the book with the sharp matte knives we use to make models. They were excavating – digging down into the "site" of the book as if it were an actual physical site for a building.

A couple of days later, I walked into the studio and each student got up to present his book. I saw a book cut up and reassembled into a cube, a book that had been sliced apart and hung up like laundry on a string, and a book that had a stepped hole cut out of the center. Each of the students had a wonderful explanation of what they had discovered. The last student presented a book that appeared untouched – no slices, no voids carved though the cover. I opened the book. The pages were blank. He had made a new identical but empty book with the same cover. I flipped through, looking for some message, and finally found a page where he had glued in the snippet of type he had excised from the book: "Knowledge is private."

Knowledge is private.

That is a very powerful and subversive statement. It says that your search in this world is compelled by your own inner need to know. It says that your ideas and your vision take time to develop and are hard-won. It says that you continue to search because you think you can do better; and the attention and approval of other people, while pleasant at best, are essentially unimportant. It says that you do not give away what you have learned promiscuously. The deepest lessons learned are not for easy public consumption.

Knowledge is private.

Since this is a quote from one of America's greatest architects, one wonders how this applies to architecture, which is the most public of arts. After all, we work for clients, so approval is a necessary ingredient – and a lot of approval brings attention. The term "starchitect" has been coined, and the attention paid to architecture today is huge. Obviously we are the beneficiaries of this attention. But the attention is also deeply detrimental. Buildings have become trophies and, aided by the instant power of the digitally communicated image, are the most visible component of "branding" – the creation of a media identity. We see images of buildings that sell us an idea, whether it is the shimmering mirage of Abu Dhabi as a cultural oasis; the sealed mirrored glass towers being erected in Bangalore, Hyderabad, and Chennai (where the temperature and the humidity both hover in the nineties) as emblems of the forward-thinking IT industry; or the mass importation of Western architects to China as a kind of self-imposed, self-purchased form of cultural imperialism.

I believe that a huge part of the power of architecture lies inside. This is what touches people, what comforts them, what makes memories. The interior has an emotional power that the exterior can seldom match.

Much of what is published today is generated to present a powerful and immediate image – a quick look, pow, and you get it. This perception of architecture is all about the outside. It is effect, not affect. It is about the object in space, not the space in the object. But the space inside the object is the heart of the matter. We live our lives inside. The facade, like a person's appearance, can attract – but it is the interior life that defines both the building and the human being.

I am an American-born Chinese. We call ourselves "ABC." So while I am culturally American, I am psychologically Chinese. This means I keep most of my feelings inside. When I get angry, I am quiet. The angrier I am, the quieter I am. Tod says that I put up the great wall of silence. Like the Great Wall of China, he says it lasts a long time and runs for thousands of miles. So for me, what is held inside is equally if not more important than what is expressed on the outside.

I believe that a huge part of the power of architecture lies inside. This is what touches people, what comforts them, what makes memories. The interior has an emotional power that the exterior can seldom match. Think of the space you saw as a child just before the lights were turned off at night. Think of the first time you walked into the Pantheon and looked up at the sky. This is one of the most powerful architectural experiences in the world, but the outside is mute. Vitruvius said that good buildings balance and satisfy three criteria: firmness, commodity, and delight. Note that these attributes focus on how one experiences the space – not on how it appears.

I became an architect because it is a marriage of use and art. You solve a problem and you simultaneously try to transcend the problem. Kahn spoke of his pursuit of architecture as moving from the immeasurable to the measurable and back to the immeasurable. One begins with the aspirations and desires of the client and the architect. They are immeasurable. They are given presence in the design of the building. The architecture becomes measurable as space is dimensioned, materials are chosen, and the facades are drawn. But the final result must be immeasurable. It should speak to greater needs than the immediate program. It should touch the soul.

Today, when architecture is seen as a commodity, we too often embrace the measurable – the understandable – as the end product because it is an image that is easily digestible and disseminated. But great architecture will take us on a quiet, slower journey inside the building and inside ourselves to that immeasurable place that is not the perception, but is the experience, of a building. This is the deepest, most profound knowledge of architecture, and it is private.

Robert J. Zimmer

President, University of Chicago

One of the questions I am frequently asked concerns the relationship between being a mathematician and being a university president. And as a mathematician, I am also frequently asked about the relationship between mathematics and music. These questions are generally asked with rather different tones. The question about the roles of mathematician and president often has an inadequately masked undertone of incredulity. On the other hand, the question about mathematics and music is generally asked with an optimistic hope of insight into some deep level of cognitive function.

An analogy I like to use about mathematics and music, and indeed about university presidencies as well, is that of a conductor of an orchestra. If you were a naïve person who knew nothing about an orchestra and you saw one play, you might comment that all the music is actually being made by the persons with the instruments. You might wonder why that person is standing there with a stick, waving his or her hands. Is the conductor actually contributing anything? One can ask an analogous question about university presidents. Isn't all the real work of the university being done by the faculty and students, with the president doing something analogous to just waving his or her arms about? Some in this room may even harbor such suspicions.

One of the functions of a conductor is to illuminate the structure of the music. By structure, I mean how the components fit together and relate to each other to form a greater whole. The whole is not merely the union of the parts; it incorporates, in addition, the relationship of the constituents to each other. The orchestra is no more a collection of independent musicians playing than a city is simply the collection of its inhabitants or a person the union of cells. Similarly, a university is much more than simply a collection of talented faculty and students. Universities have a structure whose purpose should be to create a research and educational environment that enhances the work of individuals through a sometimes complex set of relationships, thereby making the whole greater. In fact, this structure makes possible what we understand as a university, and it is the health of this structure that is ultimately the president's responsibility to foster and oversee.

A university is much more than simply a collection of talented faculty and students. Universities have a structure whose purpose should be to create a research and educational environment that enhances the work of individuals through a sometimes complex set of relationships, thereby making the whole greater.

Now let me turn to mathematics for a moment. A great deal of mathematics is in fact concerned precisely with structure. To take a familiar example, let us consider the humble triangle, which we all remember from plane geometry. At its simplest level, a triangle is just a geometric shape with three straight line segments as its sides. A naïve person, in looking at a triangle, might think there is not much more to say. If this were the case, much of plane geometry would amount to drawing straight lines and counting. But with a little thought, we realize that sides have lengths, and with a little more thought, we discover angles, which is really a subtler notion about the relationship of two lines. Now one has three sides, three lengths, three angles, and one can ask about the relationship of all these. In fact, the geometry of triangles that we all learned about many years ago is about the relationship of these constituents and how they relate to the whole, where the "whole" includes the question of what it means for two triangles to really be the same. If one simply observes the parts, namely three sides, and that they are there, without focusing on the relationships of the parts, the loss in understanding is dramatic.

This focus on structure and relationships pervades a great deal of mathematics. So as a mathematician, much as with an orchestra conductor, one's job is to illuminate structure through the understanding of the relationship of the constituents, and how the various forces and constituents at play become incorporated into the whole. Writing a sophisticated mathematics proof is akin to orchestrating a collection of relationships between ideas into something more meaningful and illuminating than these ideas are by themselves.

Some of you are surely sitting there thinking that these remarks about structure and relationships could apply to almost any subject or activity that has any complexity and depth. This is largely true, but as a society we give inadequate attention to this perspective. Albert Einstein made an oft-quoted remark about trying to make everything as simple as possible but no simpler. The public discourse on a wide array of important topics most often focuses on only the first part of this admonition – making everything as simple as possible – but often ignores the latter caution – but no simpler.

Public discourse and public policy often lack a structural perspective, approaching problems by isolating one or two components. The multiple components of the problem, and, importantly, their relationships to each other, are often unacknowledged, unanalyzed, or unappreciated. Universities have a key role to play in these matters not only because they

provide analytic understanding of these components, which itself is often not easy. They also can focus attention on and analyze the total structure and set of relationships, particularly (and this is an important caveat) if their own internal structures foster this activity. In other words, universities, at their best, can and should be a venue for the second part of Einstein's admonition – but no simpler.

Interestingly, for certain problems, mathematics makes a return entry here due in part to evolving technology. Although the components of a triangle and their relationships entail a relatively small amount of information, many modern problems, while still about the relationship of components to each other and to the whole, entail managing massive amounts of data. The power of the digital computer has led to a new capacity for computationally oriented mathematics to contribute to reconceptualizing and analyzing complex structural problems, particularly as a tool for integrating the properties of components and their relationships into properties of a whole complex system. The increasing sophistication of modeling global climate change or the relationship of the human genome to organism-level properties such as health and disease, and the increasing sophistication of spatial or geographic methods in the social sciences, are but a few salient examples of this newfound power. The computational mathematics approach to structural complexity is promising in many areas; however, when applied to many others, it is still in its infancy, with its ultimate utility yet to be explored. Ensuring that universities are structured and equipped to deal with these evolving intellectual opportunities is itself an example of a challenge of university leadership.

My comments today have focused on a conceptual relationship between two sectors of my professional life. The one further comment about my professional life that I would add is how much I appreciate joining this distinguished collection of individuals who, taken together, form such an extraordinary whole.

Jessye Norman

Opera and Concert Artist, New York, NY

[Editor's note: Jessye Norman sang "America the Beautiful" at the beginning of her presentation.]

Good afternoon, ladies and gentlemen, Fellows of the Academy, family members and friends. "One's life has value so long as one attributes value to the lives of others by means of love, friendship, indignation, and compassion." Thus wrote Simone de Beauvoir. It is clear to me that the American Academy of Arts and Sciences could well have created this beautiful phrase and to have adopted it as its mission statement. Concern for the people of our world and for the planet upon which we tread is at the forefront of the ideals of this wondrous institution. I am honored to be a part of you.

It was Abraham Lincoln who spoke of the tendency to show concern for one's fellow man as representing the better angels of our nature. As have all of you, I have taken this statement to heart as well.

Allow me to share with you one of my principal concerns, something about which I am passionate and about which I am pleased to speak at every opportunity. And that is the necessity of the arts in our lives, the need for the arts in the education of our children.

I do not mean only the home that I have found in music, but all of the arts, from the written word to the most ephemeral dance step, from the most permanent of carvings in wood or stone to a canvas so covered in ideas that it simply takes the breath away.

Art brings us together as a family because it is an individual expression of universal human experience. We have so much more in common than we acknowledge.

Expressions through art come from that part of us that is without fear, prejudice, malice, or any of the other things that we create to separate ourselves, one from the other. Art makes each of us whole by insisting that we use all of our senses, our heads, and our hearts, that we express with our voices, our hands, our bodies, as well as our minds. And in this modern society, art may be the only force that invites expression from the inside out, where the pure light of the wisdom of the soul, unimpeded, is realized.

Allow me to share with you one of my principal concerns. And that is the necessity of the arts in our lives, the need for the arts in the education of our children.

Albert Einstein said, "When I examine myself and my method of thought, I come to the conclusion that the gift of fantasy has meant more to me than my talent for absorbing knowledge." Truly, do we need further proof of the benefits of creativity, of fantasy, in our lives?

Over the years, students of the arts have outperformed their non-arts peers in all of their subjects. Study upon study has shown this to be so. Creativity equals self-knowledge. Knowledge can lead to wisdom, and wisdom can lead to the understanding of others, and this understanding undoubtedly leads to tolerance. Can creativity do all this? Yes, it can.

I tell you this because we are at a crucial point in our nation's history. On the one side is this wisdom of creativity, on the other is the backlash: the fervent belief that going back to basics, turning away from the individual toward uniform education with emphasis solely on the sciences and mathematics and forgetting the souls and the spirits of children, represents the answer to our deficient schools. I beg, most respectfully, to differ.

The discipline acquired through the study of and participation in the arts – the simple act of repetition, for example, in order to become better at doing something – lifts a student's overall scholastic abilities and self-awareness. It provides knowledge that an inner life, an inner voice, can be heard.

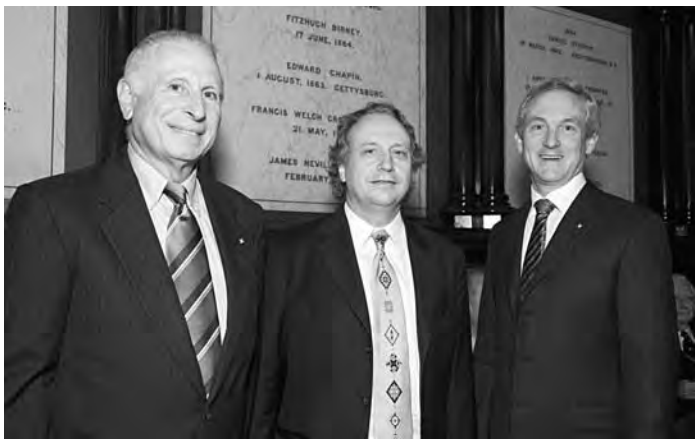
The backlash plays on our understandable despair that many children are indeed being left behind – and I use this phrase not as a political sound bite of expediency or pretense, but because we must recognize the danger of putting aside our responsibility to offer children a bright and beautiful path to positive self-expression. When our school systems say that they must save money, the arts are the first subjects to go. We must say no to this.

Use whatever means you have to include the arts as core content in your local and state schools' curricula. Remember your own educational experience, and what made you want to learn, what made you want to be in school, what made arts study fun: the choir, the marching band, the dance group, the wonderful new chemistry lab, the young and handsome art appreciation teacher.

Resolve to become acquainted with the teachings of your own heart, or as I always call this, your soul's music. And imagine, if you will, the harmony that this could bring to our world. Resolve to make sure that today's young minds are nourished completely and that their spirits are encouraged to fly. ■

Councilor Randy W. Schekman (University of California, Berkeley), new member Bonnie Bassler (Princeton University), Councilor and Trust member David Sabatini (NYU), and Secretary of the Academy Jerrold Meinwald (Cornell University)

Chair of the Academy Trust and Vice President Louis W. Cabot (Cabot-Wellington, LLC) and Bernard M. Gordon '07 (Neurologica Corporation)



Trust member Arthur Gelb (Four Signa Corporation), Rodney Brooks '07 (MIT/iRobot Corporation), and Trust member Tom Leighton (Akamai Technologies/MIT)

Projects and Studies

At a morning orientation program for new members, held on October 6, 2007, leaders of current Academy projects presented updates on their work. Their remarks appear below.

Panel I: Challenges for Science, Technology, and Global Security

Initiative for Science, Engineering, and Technology

Neal Lane

Malcolm Gillis University Professor, Rice University

I have been asked to speak about the Academy's Initiative for Science, Engineering, and Technology, which I cochair with Charles Vest, President of the National Academy of Engineering and former President of MIT. Over the past 60 years, the role of science, engineering, and technology in our lives has changed quite dramatically, and the pace of change is accelerating. The United States' leadership role is no longer guaranteed. The production and funding of scientific and engineering research are changing throughout the world, especially in Asia. A few days ago we recalled the fiftieth anniversary of Sputnik and the surge of investment in scientific research and science-mathematics education that followed in the United States. But today, in this country, science is increasingly viewed as a cost rather than as an investment. Issues for which science is crucial, for example, stem cell research and climate change, are increasingly complex, and they strike dissonant cultural and political chords in our society. The purpose of this initiative is to think broadly about the role that science and technology play in society today, how that role has changed, and how we can better prepare for the future.

It is fair to ask what the Academy can contribute that other organizations are not already doing. First, the Academy is not a science-advocacy organization.

The purpose of this initiative is to think broadly about the role that science and technology play in society today, how that role has changed, and how we can better prepare for the future.

With its strong, distinguished, and long history, with the breadth of its membership, and with its extraordinary convening power, the Academy is well positioned to contribute a unique perspective. Second, the Academy is not in Washington. After spending many years in Washington – and some of you in the audience have had the same experience – I can tell you how difficult it is to get around entrenched viewpoints in that town. Finally, the Academy is not a university. Many of the issues concerning science and its future will benefit from cross-institutional discussions. The Academy can convene many of the brightest people from a variety of institutional sectors, such as scholars, administrators, business leaders, entrepreneurs, and policymakers.

The Initiative is now in its second year, and several projects have emerged under its direction. One project is examining alternative models for federal funding of science, with a particular focus on two specific and related issues: funding for early-career scientists, engineers, and mathematics researchers; and funding for high-risk, high-reward research, sometimes called transformative research. Both, we believe, are critical to the future of science, engineering, and technology in

Selected leaders of current Academy projects: front (left to right): Patricia Meyer Spacks (University of Virginia), David Clark (MIT), Rakesh Khurana (Harvard Business School), Gerald Rosenfeld (Rothschild North America and New York University); back (left to right): Neal Lane (Rice University), Steven E. Miller (Harvard University), Loren F. Ghiglione (Northwestern University), Linda Greenhouse (The New York Times), Robert C. Post (Yale University), Joel E. Cohen (Rockefeller and Columbia Universities)

this country. Tom Cech, Nobel Laureate and President of the Howard Hughes Medical Institute, is chairing this study, and I and several others in the room are members of the committee. While many reports have recommended increased funding for science and engineering research, which we do not oppose, that is not the focus of this particular study. The committee will analyze and recommend improvements in the investment policies, the funding mechanisms, the management processes, and in the way government goes about funding research. Some of the questions the committee will ask include: What are the effects of boom and bust funding cycles? NIH just went through a doubling of its budget, but all is not well; we need to understand and help explain that situation. What mechanisms do federal agencies have in place to insure that funding flows to early career investigators, and how do agencies evaluate failure? By failure, we mean a less exciting outcome, perhaps, than what you had in mind when you submitted the proposal. The committee has heard from federal funding agencies, private funders, early-career scientists, and Congressional staffers. We hope to complete the report by spring of 2008.

A second project under this Initiative is looking at science and the liberal arts curriculum; it is chaired by Academy Secretary Jerrold Meinwald of Cornell University and John Hildebrand of the University of Arizona. The project focuses on what nonscience and nonengineering majors learn about science and technology, and how this knowledge informs their ability to become successful, active, and engaged citizens. We realize that the majority of college and university students do not major in science and engineering, and yet science, engineering, and technology affect many aspects of their lives, from managing their own health care to issues of national concern, such as energy and the environment. The project's central goal is to promote cross-institutional sharing. The Academy involved 41 colleges and universities from across the country, many of them University Affiliates of the Academy, in this study. Officials from these institutions completed surveys on curricular practices at their respective colleges and universities. This past August the Academy convened representatives from these institutions, including scientists and nonscientists, faculty and deans, to discuss the results of the survey and share best practices and innovative teaching approaches.

A third project emerging under the Initiative concerns scientists and their understanding of the public. There have been many studies on how the public can better understand science. This project approaches the subject from the other direction. We believe we need more of a dialogue than we have had in the past. Scientists do not always understand the larger context of their work and how the public views science, engineering, and technology. We need that understanding, and this project will help us get there. We welcome your ideas and involvement.

The Global Nuclear Future

Steven E. Miller

Director, International Security Program, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University

It is my privilege to represent the Committee on International Security Studies, which is one of the longest standing research groups within the Academy. Its work, going back at least five decades, has played a major role in the nation's thinking about national security affairs.

In a characteristically vivid phrase, Bertrand Russell once wrote that the challenge nuclear weapons pose to mankind is to manage this technology without a catastrophic mistake "until the sun grows cold." While we can take some comfort in the fact that we have navigated safely the first six decades of the nuclear age – although not without some frightening moments – the real challenge is navigating the eternity that lies ahead.

What is motivating one of the Academy's new initiatives is the growing feeling in the expert community – and to some extent in the policy world – that the answers of the past are no longer adequate or appropriate for the nuclear challenges of today. The strategic arms control process that governed and stabilized most of the nuclear weapons on the planet in the Soviet-American context is now being dismantled or is in some state of suspended animation. The nonproliferation regime, which is meant to inhibit, or prevent, the spread of nuclear weapons, is eroding. The crises over Iran, Iraq, and North Korea all have at their centers the threat of a spread of nuclear weapons. What we see is disaffection from all sides: nuclear weapons states, non-nuclear weapons states, and leading Third World states are dissatisfied with the existing political, legal, and institutional infrastructure for governing the nuclear affairs of the planet.

We see a tremendous upsurge in interest in pursuing nuclear power not only because of energy security but also because of global climate change.... Can the United States promote the peaceful use of nuclear energy around the globe without encouraging a similar increase in nuclear proliferation?

Meanwhile, we seem to be entering an era in which nuclear technology is growing and spreading, particularly in the civil nuclear arena. We see a tremendous upsurge in interest in pursuing nuclear power not only because of energy security but also because of global climate change and the need to retreat from excessive reliance on fossil fuels. Even in the United States, whose nuclear industry has long been stagnant, there is for the first time in several decades a license request for a new nuclear power plant. More significantly, today there are several dozen reactors under construction and even more dozens being planned around the world, many of them in developing

countries. Of course, one of the fundamental realities of nuclear technology is that many of the key components have a dual use: they have applications and implications for both weapons and power generation. If nuclear power spreads widely, the confrontation with Iran could become the template for future problems, as states regarded by Washington as unfriendly, hostile, or irresponsible develop allegedly "peaceful" nuclear programs that excite fears that the true purpose is the acquisition of nuclear weapons. How is the world going to cope with this dilemma?

There is a burgeoning sense that we are approaching a fateful juncture. This past spring, former Senator Sam Nunn argued passionately before Congress that we are nearing a nuclear tipping point and we need a fundamental rethinking of the whole nuclear question. This is a challenge that is worthy of both our time and energies, and it is completely consistent with the Academy's mission of bringing intellectual resources to bear on major national and international problems.

The Committee on International Security Studies has launched a project on the Global Nuclear Future that will examine not only the path that we are on but where we are headed. What alternative futures might exist? And if there are preferable nuclear futures, how do we attain them?

We are trying to mobilize the nuclear community to address what we see as four families of questions. One is how to manage the expansion of civil nuclear power in such a way that we do not exacerbate the problem of nuclear proliferation. If we are going to have two or three or ten times as many reactors in the world in 20 or 50 years, how do we create the legal and institutional infrastructure to insure that generating nuclear electricity does not also produce nuclear weapons around the world? Second, if we are going to have many more nuclear facilities around the world, it is imperative that these facilities have adequate safety and security measures so that the threat of terrorism or accident is kept to a minimum. Third, how do we manage nuclear stability in a changing world? How do we stabilize an environment in which Iran has nuclear weapons, or in which the nuclear crisis is no longer between Moscow and Washington but between Islamabad and Delhi? Are old concepts really applicable in these new contexts? It does not take much thought to realize that many of the factors that made for stability in the Soviet-American context simply do not exist in other regional settings.

Finally, what should America's nuclear posture be in the context of these wider nuclear challenges? We are launching a new project that will ask what America's nuclear posture should be in the context of these wider nuclear challenges. Currently we possess 10,000 nuclear weapons. We still have a nuclear-reliant defense posture. We still have a first-use nuclear policy. We still have objections to fulfilling our obligation under Article VI of the Nuclear Nonproliferation Treaty to eliminate nuclear weapons from the U.S. arsenal. What effect does that have? What alternatives exist for American policy? Can the United States promote the peaceful use of nuclear energy around the globe without encouraging a similar increase in nuclear proliferation? How can we best create the nuclear future for our society that maximizes our own safety and also that of the planet? These are the challenges to which we hope to contribute in the coming two to three years.

Securing the Internet as Public Space

David Clark

Senior Research Scientist, Massachusetts Institute of Technology, Computer Science and Artificial Intelligence Laboratory

I would like to frame the Academy's study on Internet security by telling you a story. You may recall that in April of this year the government of Estonia moved a World War II memorial, a statue of a Russian soldier, from its traditional position to a less prestigious position in a military cemetery. Ethnic Russians in Estonia protested. There were two days of riots, a weeklong siege of the Estonian Embassy in Moscow, and closer to the point of this study, a concerted attack on the computer and network infrastructure of Estonia – what we call a cyber attack or a distributed denial of service attack. Hundreds of thousands of computers simultaneously launched floods of traffic on targeted machines in Estonia. This attack clogged computers and networks, and brought the network infrastructure to its knees.

Now, you might reasonably ask, "How could an attacker get access to hundreds of thousands of machines to carry out this attack?" One machine that might have participated in this attack is *your* machine, the one you left connected to the Internet when you came to Induction. It might surprise you to know that the machine that you thought was just sitting there, waiting for you to tell it what to do, had gone off and attacked Estonia when you were not paying attention. But it could have happened.

So, how did your innocent machine get recruited into this exploit? One answer is malware, a nasty little piece of code running on your machine. Malware allows your machine to receive instructions from an evil master somewhere else on the globe. An attacker may have sent instructions to your computer to march off and attack Estonia.

Well, how did that piece of code get onto your computer? There are a variety of ways it might have gotten there, but one way is through your invitation. You went to a perfectly innocent website and clicked on what you thought was a perfectly innocent webpage. But that webpage had an interesting side effect: it crammed a piece of code down into your computer, and the code started running.

It is tempting to think of the security of the Internet as a purely technical problem. . . . But when systems designers knowingly install flaws into a system because they see the benefits as outweighing the costs, it becomes a social, legal, and policy problem.

Now you might be wondering: How did the website get contaminated? I did not go to an "evil" website. I only go to innocent websites. And, second, why did that website have permission to download and start a piece of code on my computer without

asking my permission? Let me start with the first question and teach you some vocabulary as well. In the trade, a computer that has been infested with one of these programs that allows somebody else to take it over is called a zombie. When we have a lot of zombies, we call them a botnet, where 'bot' is short for robot. We call the owner of a botnet the bot master or bot herder. (We have this theory that if you cannot solve a problem, you can give it a cute name.)

When the aspiring bot master wants to build a botnet, he looks for any website that appears inadequately administered and insecure. He then craftily attacks the website so its owner never notices. He will creep in, attach a little piece of code to a page that will cause a machine opening that page to download something, creep out again, and then sit and wait for machines to get infested as they touch this webpage. This method is called "drive-by infestation," or "drive-by downloads." As each machine gets infested it sends a message to the bot master, and when he has tens of thousands of machines he puts his botnet to work.

Let us return to the Estonia attack for a minute. One of the interesting things is that the attack was immediate. The attackers did not have a chance to build their own botnet. But in this world you do not have to build your own botnet; you just go and rent one. Building and renting botnets is now a specialty business. What this means is people are invading your machine, taking its unused processing capacity, and selling it on the black market. Some botnets are huge. The Dutch government recently broke up a botnet that had one and a half million machines on it.

Let me come back to my second question. Why was it that a webpage could download a piece of code onto your machine without asking your permission? Well, as the web evolved – and this was not Tim Berners-Lee's original vision when he invented the web, by any means – the designers wanted to be able to load new features onto your computer that did not require any effort on your part. They wanted a world where they could download code onto your machine to "enhance" the experience of using their website. They pushed this design despite the fact that security folks were standing on the sidelines saying, "Don't do this." It was a conscious, fully informed decision to sell you a machine that was open to these sorts of attacks by people who had other priorities.

The goal of the Academy study is to look at the security of the Internet. It is tempting to think of this as a purely technical problem – just beat the geeks with sticks until they get it right – and that may be correct in some cases. But when systems designers knowingly install flaws into a system because they see the benefits as outweighing the costs, it becomes a social, legal, and policy problem. To really understand security and the Internet, you must assemble a multidisciplinary team because you have to put your arms around some really big issues. And, in fact, we have struggled because the problem is so big and multidimensional. It involves looking at technical problems, matters of trust, perceptions of risk, and issues of incentives.

The Academy, with its multidisciplinary membership, is a great place to undertake a study like this. So stay tuned, and when you leave home, turn off your computer.

Panel II: Challenges for Education, Humanities and Culture

Universal Basic and Secondary Education

Joel E. Cohen

Abby Rockefeller Mauzé Professor of Populations, Rockefeller University and Columbia University

In 1997, I had a conversation with Leslie Berlowitz about the idea of providing all children in the world with the equivalent of 10 to 12 years of schooling of high quality. Leslie's vision and the collaboration of David Bloom, an Academy Fellow at the Harvard School of Public Health, led to the creation of the Universal Basic and Secondary Education (UBASE) project. We brought together people from diverse continents, cultures, and fields of learning and action to consider what it would take to educate all the world's children well for 10 to 12 years, and what kind of a world could result from universal basic and secondary education.

Why is educating all the world's children well important? Education, if wisely oriented, can benefit individuals and societies demographically, economically, environmentally, and culturally (including politically). Here I sketch some economic and demographic aspects of the promise of educating all the world's children well.

In 1900, there were 1.6 billion people in the world. In 2001, by World Bank estimates, about 2.7 billion people, nearly 53 percent of the developing world's 5.2 billion people, were living on the equivalent of $2.15 a day or less (in 1993 U.S. dollars at purchasing power parity). That is poverty. Essentially nobody in the developed countries lived on income that low. More people live in poverty today than were alive in 1900.

By the year 2050, the United Nations Population Division anticipates adding to today's population about 2.6 billion people if men and women continue to have fewer children as suggested by the decline in fertility over the last 40 years. Virtually all of those additional 2.6 billion people will live in the cities of the presently poor countries. If couples have, on average, half a child more than forecast over the next 45 years, we will have by the year 2050 about 1.5 billion more people than anticipated. If couples have, on average, half a child less, we will have by 2050 about 1.4 billion fewer people than anticipated. A difference of one child per woman's lifetime between now and 2050 entails a difference in the Earth's population of nearly 3 billion people, which was the total population of the Earth in 1960.

In diverse cultures around the world, women who complete secondary education have, on average, at least 1.5 children fewer than women who complete only primary education, who in turn have fewer children than women who do not complete primary education; and the higher the level of the mother's education, the better the health and survival of her children. The average number of children per woman's lifetime associated with each level of a mother's education varies widely from culture to culture, and in many places the average difference associated with completing secondary education is far larger than a reduction of 1.5 children. Of course, causality runs both ways between education and numbers of children, since girls who get pregnant leave or cannot enter school in many cultures.

What we do to educate men and women from now to 2050 will

What we do to educate men and women from now to 2050 will affect enormously, in addition to the numbers of people on the Earth in 2050, their survival, health, human rights, environment, capacity for self-governance, and prosperity.

affect enormously, in addition to the numbers of people on the Earth in 2050, their survival, health, human rights, environment, capacity for self-governance, and prosperity.

In many societies, fewer girls than boys enroll and remain in primary school. The educational gap between boys and girls is a problem for many reasons, ethical as well as practical. But, according to Deon Filmer at the World Bank, the gap in primary school participation between the top and the bottom quintiles in the income distribution is much greater than the gap between boys and girls, and the gap in school participation is even greater for children with disabilities than for girls or the poor. The challenges facing universal education include reaching girls, the poor, and the disabled.

The UBASE project aimed to find out how much it would cost to educate all children. Could countries afford to put all children in school for 10 to 12 years or to give them an equivalent education? That question is difficult to answer for at least four reasons (in addition to the paucity of accurate, internationally comparable data).

First, the average cost of educating a child who is not currently in school probably differs from the average cost of educating a child who currently is. The child not in school now may be disabled, may live in a remote rural location, or may have some other handicap. Moreover, supplying a high-quality education to a poor child may, on average, require more in-school resources than are currently expended on the better-off students currently enrolled.

Second, the average cost of enrolling an unenrolled child may be higher than the average cost per currently enrolled student because it may be necessary to compensate families who keep their children at home for the time children spend working for income or handling chores so other household members can work for pay.

For these two reasons, a linear extrapolation from the costs per child already in school to the cost per child not yet in school is speculative.

Third, we do not know how much it would cost to improve the quality of schooling so that parents will want to send their kids to school, rather than send them out to work or keep them home for chores.

Fourth, we do not know by what means people will be educated 20 years from now. Will they be taught in schools? Will they be taught with cell phones, or with MIT's $100 computer, or with the UK's Nivo, or with India's Simputer? Or in some other completely different way?

Despite these difficulties, as part of our project Paul Glewwe and Meng Zhao (for primary schooling) and Melissa Binder (for secondary schooling) estimated that all children could be given the equivalent of a decent primary and secondary education for an additional cost, on top of what developing countries are already spending to educate their children, of probably not more than $70 billion per year. In 2000, for the low- and middle-income countries (about 5.1 billion people), the incremental cost of $70 billion per year would amount to about 1.2 percent of their gross national income (GNI). The GNI of the high-income countries (with about 1 billion people in 2000) was about $25.5 trillion of the world's $31.5 trillion, and an incremental cost of $70 billion per year would amount to less than 0.3 percent of their GNI. The world, collectively, can afford to educate all its children well, but the poor countries will need some help from the rich countries. The amounts of money needed could be well above the current level of foreign aid but are feasible if the will is present (as the Marshall Plan demonstrated).

Cost is one of several obstacles to universal basic and secondary education. Like cost, none of these additional concerns is insurmountable if all are recognized and dealt with. Competing demands: Education competes for scarce national resources with roads, medical care, and defense. Returns on investment in education are difficult to measure. Lack of information: Internationally comparable, useful data on the quality of primary and secondary schooling are lacking. Political obstacles: Benefits of schooling accrue too slowly to benefit political incumbents. Violence disrupts schools. Cultural barriers: Discrimination inhibits schooling for girls and for linguistic, religious, and ethnic minorities. Historical context: The history of education in a country affects the success of externally imposed educational solutions.

In January 2007, MIT Press published the UBASE project's first book, entitled *Educating All Children: A Global Agenda*, which I edited with David Bloom and the Academy's program officer Martin Malin, now at Harvard. In it, and in an article for the International Monetary Fund's journal *Finance & Development*, we identified a number of changes that need to be implemented simultaneously:

- a commitment to extending secondary education of high quality to all children;
- open national, regional, and international discussions on the goals of universal primary and secondary education – that is, what do people want education to achieve?
- a commitment to improving the effectiveness and economic efficiency of education in achieving those goals; this improvement should be driven by reliable data on what children learn; careful experiments with alternative pedagogical techniques and technologies; and comparative studies of the countries that perform best, region by region, with given funding and material resources;
- international recognition of the diversity of educational systems in different countries, and adaptation of aid policies and educational assessment requirements to local contexts;
- more money and higher priority for education – especially an increase in the absolute and relative amount of funding from rich countries for education in poor countries.

Universal high-quality primary and secondary education, wheth-

er through schools or other technologies yet to be developed, is achievable. The sooner and the greater our efforts to achieve universal high-quality primary and secondary education now, the greater the demographic, economic, environmental, and cultural impacts by 2050. Educating all children well – quality counts crucially – is a worthwhile, affordable, and achievable strategy to develop people who can cope with problems, foreseen and unforeseen.*

**I thank David E. Bloom for very helpful comments on a prior draft.*

Initiative for Humanities and Culture

Patricia Meyer Spacks

Edgar F. Shannon Professor of English Emerita, University of Virginia

The Academy's Humanities Initiative aspires to make the importance, the meaning, and the history of the humanities more widely comprehensible. At the moment, the Initiative is concentrating on two projects: one involves the collection and organization of data; the other focuses on compiling a collection of essays by academic leaders that will assess the current condition of the humanities.

Humanists, as you may know, often see themselves as being in a state of crisis. This is one of the crisis periods. Widespread perception has it that the place of the humanities in higher education and in popular opinion is diminishing, but do the facts support the perception? Both our projects will help to answer this question. In the short time that I have, however, I would like to concentrate on the project that involves the collection of data.

The Humanities Indicators Project, as we call it, is an ambitious effort to move toward creating an annual compilation of relevant data for the humanities. At present, rational discussion is impeded by the fact that no one really knows much about what is going on in the assortment of academic fields designated as the humanities. Unlike scientists and engineers, humanists have never had available to them a single dependable source of data about their field. The *Science and Engineering Indicators*, issued biennially by the National Science Foundation, provide information about education and employment over a wide disciplinary range. In the humanities, professional organizations have tried to assemble facts about developments within their disciplines, but the data among fields are generally not compatible since different organizations employ different means of gathering data and different ways of codifying them. You would have a hard time finding out how many undergraduates now major in the humanities, and if you did find out, you could not compare your figure with the number of majors ten years ago, much less twenty years ago.

The American Academy has set out to facilitate the inauguration of a comprehensive system for accumulating and organizing basic information about education and employment in the humanistic disciplines. How many people major? How many take courses? How many get advanced degrees in these fields? What do people with Ph.D.s in the humanities do for a living? How much teaching in humanistic areas is done by part-time faculty? These are the sorts of questions we have in mind. The enterprise involves

The American Academy has set out to facilitate the inauguration of a comprehensive system for accumulating and organizing basic information about education and employment in the humanistic disciplines.

figuring out how best to make use of existing data, as well as how to gather new information. It has required the collaboration of men and women from many disciplines: statisticians, social scientists, and humanists – the kind of collaboration that the Academy facilitates. It has also involved many organizations, including the National Science Foundation and the learned societies under the umbrella of the American Council of Learned Societies. And thanks to foundation support and to the leadership of Norman Bradburn of the National Opinion Research Center at the University of Chicago, it is finally happening.

The effort to organize data has proved enormously complicated, but the initial project is now moving toward completion. Professor Bradburn and his assistants are putting together a prototype compilation. It remains to be seen whether the resources will be available to continue updating the available information. This initial version is showing good news and bad news for the humanities. Let me offer a few examples. On the positive side, there turns out to be high job satisfaction among humanities graduates, who believe, by and large, that their education has equipped them well for the work they do. In liberal arts colleges, humanities faculty continue to constitute the most significant portion of all faculty. They also have an impressive presence on two-year college campuses, although most of those teachers do not have Ph.D.s. The humanities has nearly achieved gender parity in its faculty, although in 2004 women still represented less than 40 percent of tenured faculty.

The news about parity, though, is less good than it seems. Although in 2004, 60 percent of doctoral recipients in the humanities were women, the percentage of tenure-track faculty who are women has dropped steadily since 1993. This disconcerting fact means not only that future prospects for tenured women are declining; it also reflects the truth that a large proportion of the increasing group of part-time and adjunct faculty is female.

Most of the bad news apparent so far is fairly predictable. Humanities faculty are the lowest earners in academe, with a median salary over $30,000 lower than the median for faculty in the health sciences. Although job satisfaction among humanities professors is high, they complain about their salaries. The number of undergraduate degrees awarded in the humanities is now close to the 1970s high, but since the total number of bachelors' degrees has increased, the humanities' share has diminished, standing far below that of business, for example, which awarded 22 percent of all bachelors' degrees in 2004. Nonetheless, B.A.s in the humanities remained the third most commonly awarded undergraduate degree.

Such information constitutes only a starting point for understanding the situation of the humanities within and outside the academy. It is not, for the most part, startling, but it is vital for arriving at informed comprehension of where we are and what we should be doing. We look forward to getting more and more of it.

Academic Freedom

Robert C. Post

David Boies Professor of Law, Yale Law School

I would like to begin by expressing the hope that as new Fellows you will take advantage of the unique opportunities offered by the Academy for research and for influencing public policy. The Academy is multidisciplinary, and it is nonpartisan. It can serve as an honest broker for matters of intense and intractable public controversy. A good example is the project that I shall discuss this morning.

This project concerns academic freedom in universities. You may have noticed that universities are now at the center of numerous intense controversies involving issues of academic freedom. I am not now referring to the impact of the present war. I shall not discuss the surveillance of university libraries or the inability of graduate students to obtain visas or the new forms of secrecy that have recently evolved, like the innovative category of information that is "sensitive but not classified."

Instead, I shall address controversies that are explicitly ideological and that explicitly concern the nature of academic freedom. The Academy has assembled a committee to think about these controversies. The group consists of myself; Geoffrey Stone, a former Provost at the University of Chicago; Jonathan Cole, a former Provost at Columbia; Robert Berdahl, President of the AAU; Nancy Cantor, Chancellor at Syracuse; Larry Kramer, Dean at Stanford Law School; and Pauline Yu, President of the ACLS.

The first subject that this committee addressed is the controversy over "intellectual diversity." This principle of intellectual diversity has been at the core of much recent debate. There have been legislative initiatives in many states designed to ensure that universities maintain "intellectual diversity" on their faculty.

Of course, in the abstract, diversity may be a good thing. But too frequently the proponents of these initiatives seek to require universities to maintain a faculty that is balanced between political conservatives and liberals. Proponents of these initiatives often cite surveys purporting to demonstrate that the vast majority of certain university departments are registered Democrats rather than Republicans. They believe that the political views of faculty affect their teaching and that therefore universities ought to ensure that their faculty more fairly represent the spectrum of national political views.

I am pleased to report to you that yesterday the Council of the Academy passed a set of resolutions that were drafted by our committee on academic freedom. There are five points. The first point reads:

> It is a clear violation of academic freedom to evaluate faculty or students based upon their political beliefs or affiliations.

The third point states:

> Academic freedom requires, among other things, that individual faculty be evaluated by experts in their field based upon the quality of their scholarship, teaching, and institutional contributions. Academic freedom requires that this evaluation reflect both rigorous professional standards and the profound value of open intellectual inquiry.

Universities are now at the center of numerous intense controversies involving issues of academic freedom. . . . controversies that are explicitly ideological and that explicitly concern the nature of academic freedom.

The fourth principle declares:

> The application of professional disciplinary standards by experts in the field allows ample room for intellectual debate within the academy; it is compatible with the robust expression of different perspectives. Although colleges and universities may properly seek a faculty of widely varying views, they may not pursue this goal by considering political beliefs or affiliations.

(If you are interested in reading the complete statement of principles, you may find it on page 25 in this issue of the *Bulletin*.)

We believe that these resolutions provide a basis on which questions of "intellectual diversity" can be addressed in a manner that is consistent with academic freedom. We hope to encourage disciplinary societies to endorse these resolutions. We hope to use these resolutions to appeal to universities affiliated with the Academy to crystallize consensus among educational leaders about relevant principles of academic freedom.

The next step in our project will be to address more complicated issues. You may be aware of the many controversies in which it is contended that universities "indoctrinate" rather than "educate" their students. We hope to explore the principles of academic freedom that are relevant to such controversies. We mean to ask how education can be distinguished from indoctrination.

There is no doubt, for example, that most contemporary professors of biology teach evolution rather than intelligent design. Most professors of biology do not even refer to intelligent design. This is not uncontroversial in an era when presidential candidates profess to believe in intelligent design rather than evolution. We must ask, therefore, whether it would be a violation of academic freedom to require biology professors to offer a "balanced" presentation of these politically contentious matters.

In current debates it is commonly asserted that teaching that is not "balanced" improperly indoctrinates students. But this assertion requires analysis. If I am teaching Kant, for example, must I expose my students to the competing views of Bentham and Hume? Of the indefinitely large number of ethical views that "compete" with Kant, which ones must a professor teach in order to offer her students a "balanced" presentation? Would it violate academic freedom if a state legislature, or if the board of trustees of a private university, were to require a philosophy professor to teach Kant in a "balanced"

way? What are the precise circumstances in which a lack of balance suggests indoctrination? When and how may professors in a classroom properly offer students only one point of view about matters that are political controversial?

Some recent legislative initiatives take a different tack and seek to prohibit professors from creating a "hostile educational environment." Many important questions of academic freedom are raised by such initiatives. Would it violate academic freedom if a state were to pass a law prohibiting professors from criticizing the views of their students, if such students were to experience this criticism as creating a hostile environment? If your instinct is that such laws would infringe on academic freedom, can your instinct be reconciled with civil rights legislation that prohibits the creation of a "hostile environment" based upon race or sex?

Recent debates raise many such difficult questions. The nonpartisan, disinterested, and multidisciplinary environment of the Academy is an ideal environment in which such questions can be calmly and dispassionately evaluated. With some luck, the efforts of the Academy may influence the tenor and outcome of current disputes about the nature of academic freedom.

Panel III: Challenges for Social Policy and American Institutions

The Independence of the Judiciary

Linda Greenhouse

Supreme Court correspondent, The New York Times

Our project on the Independence of the Judiciary is in a transitional phase. In fact, it began as something else: we originally called it Congress and the Court. The project began in the late 1990s when we discerned that something quite unusual had happened in the relationship between the Supreme Court and Congress. The Court was striking down federal statutes on the grounds that Congress lacked the constitutional authority to have enacted them. The statutes were essentially a series of civil rights laws. Nothing like that had happened between the Court and Congress since the New Deal. We felt that the Academy, in its role as an honest broker, could look into what seemed to be an emerging crisis between two branches of our government. We convened a series of closed-door meetings among the stakeholders in this issue – namely, Supreme Court Justices, a number of whom are members of the Academy, and key players on the Hill – to facilitate a conversation, in the hope that discussion would lead to understanding. Eventually the crisis eased, and the Court stopped doing what it had been doing.

These issues would benefit both from public conversation and scholarly inquiry, as well as the Academy's ability to bring together people who do not usually have a forum to talk to one another.

But another problem emerged: threats to the independence of the judiciary, both at the federal and state level. The Academy has held a series of meetings about these threats; the most recent was held last April in Washington, D.C., when the Academy and the American Philosophical Society, our sister society from the founding period of the country, had its first-ever joint meeting. Sandra Day O'Connor, retired Associate Justice of the U.S. Supreme Court; Judith Kaye, Chief Judge of the State of New York; Charles Geyh, Professor of Law at Indiana University; and I participated in a panel discussion on judicial independence. We are currently working with Georgetown Law School on a publication that will touch on various aspects of this issue.

To give you a sense of the range of issues that we are exploring: Federal judges believe that the matter of compensation is a major threat to the independence of their branch. State court judges feel this too. In the middle of our panel last April, Chief Judge Kaye had to keep her cell phone on because of a crisis in the New York legislature concerning the passage of a pay increase for judges. The New York judges ended up suing the state to get more money. Last fall, a group called J.A.I.L. 4 Judges sponsored a referendum that would have imposed criminal liability on judges for making "wrong decisions." Fortunately it failed.

These issues would benefit both from public conversation and scholarly inquiry, as well as the Academy's ability to bring together people who do not usually have a forum to talk to one another. That is the premise of our project on the Independence of the Judiciary.

The Media in Society

Loren F. Ghiglione

Richard Schwarzlose Professor of Media Ethics, Northwestern University

In 2005, the Academy initiated a study of the news media, with funding from the Annenberg Foundation Trust at Sunnylands. The project first focused on informing the public and influencing policymaking in two areas: science and technology, and business and economics.

The Academy convened two groups. One, made up of scientists, science journalists, and academics, is chaired by Donald Kennedy, President Emeritus of Stanford and Editor-in-Chief of *Science*, and Geneva Overholser, former Editor of the *Des Moines Register* and now the Curtis B. Hurley Professor in Public Affairs Reporting at the Missouri School of Journalism. The study is exploring how the news media report science and technology. The other group includes advisors Alan Blinder and Alan Krueger, economists at Princeton University, and Norman Pearlstine, Senior Advisor of the Carlyle Group and former Editor-in-Chief of Time, Inc. This study is examining the reporting of business and economic policy issues. Within the next year, both study groups will prepare final reports,

It is unclear what the future media landscape will look like, except to say that it will be digital and different.

with recommendations for improving reporting in their respective areas.

Common themes have emerged from the two study groups. First, changes in technology, coupled with changes in patterns of news consumption and advertising, are eroding the income sources that have long sustained mainstream media. Second, these changes are affecting how the public receives information and how reporters gather and disseminate news.

It is unclear what the future media landscape will look like, except to say that it will be digital and different. As an outgrowth of the two study groups, the Academy convened experts in journalism and the media to consider "the future of news," with programs in New York and Washington, D.C. As a senior scholar in residence at the Academy this summer, I was invited to fashion a broader, longer-term Academy project.

The questions that might be addressed by such a project are of such urgency and enormity that they would benefit from examination by Academy members in many disciplines and fields. For example:

- What can historians, scholars of literature, and others in the humanities and arts tell us about past technological, institutional, human, and cultural change as well as the possible effects of current change and future change on journalism and the dissemination of news?
- As the news media, once society's gatekeepers, learn to live with the greater transparency of the Internet, what can we learn from philosophers and ethicists about how to increase the accountability and credibility of all those who present news?
- What can psychologists, psychiatrists, and researchers tell us about human behavior that will help the news media more effectively present accurate, fair, in-depth, and in-context information while also satisfying the public's expectation for speedier, click-of-the-button access to that information?
- Given the Academy's current focus on business and science reporting, can experts in computer sciences, technology, business, public policy, and philanthropy help redesign existing nonprofit entities or invent new ones to guarantee the future transmission of essential news, however complex? Can changes in government policy stimulate the availability of necessary news without threatening First Amendment freedoms?

Given time constraints, I will mention only three Academy initiatives that might help to answer these questions and others:

1. *Research*. The Academy's Visiting Scholars Program selects seven to eight postdoctoral scholars and junior faculty each year. Since the Visiting Scholars' offices are normally vacant from mid-May through August, they could become a temporary home for researchers addressing questions about news in a digital-age democracy.

2. *Studies*. Building on its strength as a convener of multidisciplinary groups, the Academy could form teams of news practitioners, scholars, and other experts across the disciplines to tackle multiyear projects. A team from history, literature, the arts, and other fields might, for example: conduct public presentations and conferences – with Web streaming for schools nationwide – about the impact of changing technology; produce books about the future of news and democracy (and offer free electronic versions); develop modules to invigorate the teaching of media history; stimulate the teaching of news literacy to nonjournalism students, who are increasingly amateur cell-phone producers as well as consumers of news; or create a website that invites bloggers, editorial writers, broadcasters, and the public to participate in a nationwide conversation about the impact of new technology on the news.

3. *Evaluations*. The Academy could sponsor evaluations of high-profile news media, both local and national, to examine their news performance, independence, and ethics. These evaluations, presented in print, audio, and video formats, could inform the national discussion about the role of the news media today and tomorrow.

I hope the Academy, with the help of foundations and you, will be able to undertake one or more of these initiatives. The future of news essential to a free society deserves the Academy's attention and intellectual leadership.

Leadership and Professional Responsibility

Gerald Rosenfeld

Deputy Chairman, Rothschild North America; Clinical Professor of Business, New York University

A number of years ago, Martin Lipton and Larry Sonsini, corporate lawyers, and Jay Lorsch, management scholar at the Harvard Business School, helped the Academy launch a study that was stimulated by the corporate scandals and corporate failures of the early 2000s – the Enron, WorldCom, and other well-publicized situations. The study focused largely on the role of gatekeepers

This project will focus on professional responsibility, and how it interacts in the business and corporate world as well as how it interacts in the training of young professionals across the academic community.

– namely, lawyers, accountants, corporate directors, regulators, investment bankers, and business journalists – and how they interacted in those corporate failures. The Academy convened several meetings, resulting in the publication *Restoring Trust in American Business*. The book has had a significant influence on a number of universities as well as on teachers of the gatekeeper professions.

The project is now moving into a broader study of the professions. It will focus on professional responsibility and how it interacts in the business and corporate world as well as how it interacts in the training of young professionals across the academic community. We welcome input from Fellows interested in this subject. We hope our study will be of benefit to emerging professionals, teachers of emerging professionals, and to the people who currently work across disciplines.

Rakesh Khurana

Associate Professor of Organizational Behavior, Harvard Business School

The ability of the professions, and especially the professionals, to self-govern their occupations is increasingly under question. The Academy's initial study in this area highlighted the importance of professional responsibility in business. One of the themes that came out of our study was a systematic decline in the status and nature of professions, especially business, law, journalism, accounting, and the like. In our book, we learned that terms such as professionalism have become economically untenable models for many occupations. Some contributors felt that law firms should no longer be seen as professional organizations; they are institutions organized around a market logic. Absent an energetic response by professional leadership and professional schools, we think there is the potential for a sudden collapse of a profession in a single generation, much as we saw with auditing: a highly regarded occupation, once guided by a professional ethos of serving the public interest, lost its status overnight as a consequence of accountancy's weakened professional ethos.

While many people like to think of business and management as a profession at the same level as law and medicine, they do not fall into the same category.

Another theme that emerged from our study, and this is a more complicated issue, is that while many people like to think of business and management as a profession at the same level as law and medicine, they do not fall into the same category. If we think about professions as having an agreed-upon body of knowledge; a commitment to use that knowledge to advance societal interests before private interests; and a capacity for self-regulation, which includes oaths, licensing, and certification exams, it is clear that you cannot apply those criteria to the many people who are now coming out of business schools. Lacking a better term, there has not been much work done on what we call the "protoprofessionals" – executives, boards of directors, investment bankers. While this group may claim to have a status equivalent to that of doctors, lawyers, or scientists, those claims are often not reciprocally organized insofar as a commitment to put society's interests ahead of personal interests, nor do these protoprofessionals have the institutions that really give them the hallmarks of a profession. How does this affect what is taught in business schools? What impact does it have on what is taught in law schools? How do these protoprofessions stand up against the professional institutions that I just mentioned, especially when profit goals often replace the obligation to the client or to the public?

Our universities, especially our professional schools, bear some responsibility in hastening the devolution of some of these professions. While the professional schools may be the source of the trouble, they may also be part of the solution. The knowledge and training necessary to reinvigorate the professions exist in these schools. Without their initiative, we will not be able to train a generation of students with these professional values. This is an ideal project for the Academy because it is messy, big, politically tinged, and culturally charged. For an untenured faculty member, it is a model project to undertake. ■

Joel E. Cohen

Patricia Meyer Spacks

Gerald Rosenfeld and Rakesh Khurana

David Clark and Neal Lane

Statement on Academic Freedom

An Academy study group, cochaired by **Jonathan R. Cole** (Columbia University), **Robert C. Post** (Yale Law School), and **Geoffrey R. Stone** (University of Chicago), drafted a statement on academic freedom as part of a project on challenges to higher education. The project focused on calls for intellectual diversity and the challenges such demands pose to traditional notions of academic freedom. The preamble and statement (reprinted below) were adopted by the Council of the Academy and distributed to academic leaders throughout the country. The Study Group also includes: **Robert M. Berdahl** (Association of American Universities), **Nancy E. Cantor** (Syracuse University), **Larry D. Kramer** (Stanford Law School), and **Pauline Yu** (American Council of Learned Societies).

Preamble

Citing surveys that "increasingly reveal ideological imbalance in the classroom, evidence of politicization, and public concern over these issues,"[1] groups such as Students for Academic Freedom and the American Council of Trustees and Alumni have sponsored legislative initiatives in Congress and in at least 24 state legislatures to "break the liberal hold on academia"[2] by redressing the "marked political imbalance among college faculty."[3] In essence these initiatives seek to promote "intellectual diversity"[4] among college faculty by requiring institutions of higher education to maintain a proper balance between faculty who are politically conservative and politically liberal.

In response to these initiatives, the American Academy's Initiative on Higher Education convened a study group to evaluate such legislation in light of basic principles of academic freedom. These principles hold that faculty should be judged on the professional merit of their work and not on their political affiliation or outlook. The study group has drafted a statement of basic principles. It hopes that the adoption of this statement by the Academy and other academic institutions, professional associations, and learned societies will help to counter legislative initiatives that threaten to undermine academic freedom on campuses. The Academy applauds all leaders in higher education who are willing to speak out with their boards, their faculty, their students, and their alumni wherever and whenever principles of academic freedom are threatened, and it has drafted this Statement of Principles in the expectation that it might be useful for this purpose.

[1] Language introduced into state legislation in 2007: Montana House Joint Resolution No. 55, http://data.opi.mt.gov/bills/2007/billhtml/HB0525.htm, and Georgia House Bill 154, http://www.legis.ga.gov/legis/2007_08/fulltext/hb154.htm.

[2] Jeff Emanuel, "Legislating Intellectual Diversity at Colleges Is a Slippery Slope," *Athens Banner-Herald*, March 8, 2007.

[3] American Council of Trustees and Alumni, *Intellectual Diversity: Time for Action* (2005), 2.

[4] Ibid.,1.

Statement of Principles

1. It is a clear violation of academic freedom to evaluate faculty or students based upon their political beliefs or affiliations.[5]

2. The principle of academic freedom is at the very core of American higher education. It is the *indispensable* condition for colleges and universities that seek to expand the domain of knowledge. Academic freedom enables scholars, researchers, teachers, and students to pursue their curiosity in whatever direction it leads them. Academic freedom promotes scholarly competence and achievement; it establishes open intellectual inquiry; and it has produced the extraordinary insights and discoveries that are the hallmark of American higher education. Academic freedom fosters scholarly and scientific innovation by protecting those who challenge orthodoxies. It is the responsibility of college and university trustees, administrators, faculty, and students to respect, preserve, protect, and defend academic freedom.

3. Academic freedom requires, among other things, that individual faculty be evaluated by experts in their field based upon the quality of their scholarship, teaching, and institutional contributions. Academic freedom requires that this evaluation reflect both rigorous professional standards and the profound value of open intellectual inquiry.

4. The application of professional disciplinary standards by experts in the field allows ample room for intellectual debate within the academy; it is compatible with the robust expression of different perspectives. Although colleges and universities may properly seek a faculty of widely varying views, they may not pursue this goal by considering political beliefs or affiliations.

5. In the event that there is reason to believe that discrimination among faculty on the basis of their political beliefs or affiliations has occurred, the proper remedy is through procedures established by the institution for the protection of academic freedom. It is the responsibility of colleges and universities to have in place appropriate procedures to protect and preserve academic freedom, and it is the responsibility of administrators and faculty to implement these procedures in a fair and responsible manner. ■

[5] For secular colleges and universities, it would also be a clear violation of academic freedom to evaluate faculty or students upon their religious beliefs or affiliations. This principle may not apply, however, to colleges and universities with overtly theological missions.

Visiting Scholars Program

2007–2008 Visiting Scholars: Seated: Chair of the VSP Patricia Meyer Spacks and Academy CEO Leslie C. Berlowitz Standing: David Ekbladh, Galit Sarfaty, David Sehat, Joy Rohde, John Kaag, Director of the VSP Alexandra Oleson, Lisa Fluet, and Paul MacDonald

Five years ago, on the recommendation of Chief Executive Officer Leslie C. Berlowitz, the Academy established a fellowship program for younger scholars in the humanities, social science, and policy studies. In the intervening years, the Visiting Scholars Program has broadened and enhanced every aspect of its work. Last year, candidates applied from over 60 universities in 27 states. The program's alumni are teaching and conducting research at colleges and universities throughout the country, including, among others, Brooklyn College, Boston University, Harvard University, Indiana University, MIT, Stanford University, the University of North Carolina at Chapel Hill, and the University of Western Ontario. They have published books and articles on such topics as nineteenth- and twentieth-century American history and literature; race relations; international security, including the effects of globalization; and the growth of interdisciplinary disciplines, such as urban studies and the history of science.

In addition to advancing their own research, the Academy's Visiting Scholars have an opportunity to become part of a diverse, intergenerational intellectual community. They attend Stated Meetings and are active participants in forums involving academic and cultural leaders in the Boston area. Research seminars enable Visiting Scholars to present their work to colleagues in the program and to Fellows who have a special interest in their field of study. The scholars themselves meet regularly to critique each other's chapters, papers prepared for professional meetings, and job talks. Opportunities to discuss work in progress with a critical yet supportive audience provide valuable feedback on the direction of their research and on the effectiveness of oral presentations.

This year, the Chair of the program, Patricia Meyer Spacks, Edgar F. Shannon Professor of English Emerita at the University of Virginia and former President of the Academy, has organized a series of informal conversations with Fellows at neighboring institutions. These senior scholars provide a personal perspective on their teaching and research experience and on the changing nature of their discipline. Editors from university and commercial presses also participate in the meetings, offering guidance on the revision of dissertations, on the audience for scholarly books, and on the changing economic state of the publishing industry. By incorporating such interactions in the Visiting Scholars Program, the Academy encourages new forms of collaboration, analysis, and debate and new ways of thinking about historical and contemporary issues that have no disciplinary boundaries.

The Academy is deeply grateful to the Director of the Harvard Humanities Center, Homi Bhabha, and Executive Director, Steven Biel, for providing our scholars with access to Harvard's research facilities. We are indebted to the Academy's University Affiliates and to the following foundations for their continued support of the Visiting Scholars Program: The Annenberg Foundation, The Cabot Family Charitable Trust, The Virginia Wellington Cabot Foundation, the Carl and Lily Pforzheimer Foundation, The Haar Family Endowment, and the National Endowment for the Humanities.

2007 – 2008 Visiting Scholars

David Ekbladh – Ph.D., Columbia University. B.A., American University. *The Great American Mission: Development and the Creation of an American World Order.* An exploration of how modernization evolved, in theory and practice, as a tool in U.S. foreign relations throughout the twentieth century and continues to resonate in strategies at work today.

Lisa Fluet – Assistant Professor of Twentieth-Century British and Anglophone Literature, Boston College. Ph.D., Princeton University. B.A., College of the Holy Cross. *Modernism, Human Rights, and the Novel, 1921 – 1961.* An examination of the historical relations between the modern novel and human rights discourse, from the founding of international PEN (1921) to the origins of Amnesty International (1961).

John Kaag – Ph.D., University of Oregon. M.Phil., University of Cambridge (U.K.). B.A. and M.A., Pennsylvania State University. *Thinking Through the Imagination: The Aesthetic Basis of Human Cognition.* An investigation of the central role of aesthetic imagination in the workings of the empirical sciences, employing the philosophy of Charles Sanders Peirce and William James as a theoretical frame.

Paul K. MacDonald – Ph.D., Columbia University. B.A., University of California, Berkeley. *Networks of Domination: Social Ties and Imperial Rule in International Politics.* A study of how precolonial social ties between European political agents and indigenous elites helped facilitate the imposition of imperial rule in India, South Africa, and Nigeria during the nineteenth and early twentieth centuries.

Joy Rohde – Ph.D., University of Pennsylvania. B.A., University of Chicago. *The Social Scientists' War: Expertise in a Cold War Nation.* A study of how social scientific knowledge about nation-building and revolution extended the power of intellectuals and the Pentagon over American politics and international affairs during the Cold War.

Galit Sarfaty – J.D., Yale Law School. M.A., University of Chicago. B.A., Harvard College. *Ethics and Accountability in International Law: An Ethnography of Human Rights at the World Bank.* An analysis of the organizational culture of the World Bank with a focus on the bureaucratic obstacles – including the Bank's incentive system and the power dynamics between professional subcultures – to internalizing human rights.

David Sehat – Ph.D., University of North Carolina, Chapel Hill. M.A., Rice University. B.A., Dallas Baptist University. *The American Moral Establishment: Religion in American Public Life.* An argument that U.S. law supported a religiously derived morality that functioned as an ersatz or proxy religious establishment until the 1960s.

Chair of the Visiting Scholars Program

Patricia Meyer Spacks – President of the Academy, 2001 – 2006. Edgar F. Shannon Professor of English Emerita, University of Virginia. Ph.D., University of California, Berkeley. M.A., Yale University. B.A., Rollins College. A renowned scholar of eighteenth-century literature and culture whose work encompasses issues of identity and selfhood, privacy, gossip, and feminism. Her most recent work is *Novel Beginnings: Experiments in Eighteenth-Century English Fiction*, an account of the diverse forms and themes that contributed to the development of the eighteenth-century novel.

The Academy is grateful to the individuals who served as reviewers and offered guidance for the Visiting Scholars Program over the past year:

Joyce Appleby, University of California, Los Angeles
James Axtell, College of William and Mary
Lucius Barker, Stanford University
Steven Biel, Harvard University
David Bromwich, Yale University
Ruth Butler, University of Massachusetts
Robert Campbell, *Boston Globe*
Albert Carnesale, University of California, Los Angeles
William Chafe, Duke University
Karen Cook, Stanford University
Thomas Cook, Northwestern University
Jonathan Culler, Cornell University
Eric Foner, Columbia University
Nathan Glazer, Harvard University
John Mark Hansen, University of Chicago
Neil Harris, University of Chicago
M. Kent Jennings, University of California, Santa Barbara
Robert Jervis, Columbia University
Jacqueline Jones, Brandeis University
Carl Kaysen, MIT
Alice Kessler-Harris, Columbia University
David Lake, University of California, San Diego
William McFeely, University of Georgia and Radcliffe Institute for Advanced Study
Leo Marx, MIT
Steven Miller, Harvard University
James Olney, Louisiana State University
George Rathjens, MIT
Bruce Redford, Boston University
Harriet Ritvo, MIT
Bruce Russett, Yale University
Robert Sampson, Harvard University
Eugene Skolnikoff, MIT
Werner Sollors, Harvard University
James Stimson, University of North Carolina
Judith Tick, Northeastern University

University Affiliates

The Academy is pleased to announce that Northeastern University is the newest member of the University Affiliates program, a consortium of universities and colleges from across the country that provide support and guidance for Academy research, including the Visiting Scholars Program. The Academy is grateful to the leaders of all of the University Affiliates for their support and commitment to the next generation of scholars and to examining issues of importance to higher education.

American University – Cornelius Kerwin, President

Boston College – William P. Leahy, S.J., President

Boston University – Robert A. Brown, President

Brandeis University – Jehuda Reinharz, President

Brown University – Ruth J. Simmons, President

The City University of New York – Matthew Goldstein, Chancellor

Columbia University – Lee C. Bollinger, President

Cornell University – David J. Skorton, President

Dartmouth College – James Wright, President

Duke University – Richard H. Brodhead, President

Emory University – James W. Wagner, President

George Washington University – Steven Knapp, President

Harvard University – Drew Gilpin Faust, President

Indiana University – Michael McRobbie, President

Johns Hopkins University – William R. Brody, President

Massachusetts Institute of Technology – Susan Hockfield, President

Michigan State University – Lou Anna K. Simon, President

New York University – John Sexton, President

Northeastern University – Joseph Aoun, President

Northwestern University – Henry S. Bienen, President

Ohio State University – Gordon Gee, President

Pennsylvania State University – Graham Spanier, President

Princeton University – Shirley Tilghman, President

Rice University – David W. Leebron, President

Rutgers, The State University of New Jersey – Richard L. McCormick, President

Smith College – Carol T. Christ, President

Stanford University – John L. Hennessy, President

Syracuse University – Nancy Cantor, Chancellor and President

Tufts University – Lawrence S. Bacow, President

University of California, Berkeley – Robert J. Birgeneau, Chancellor

University of California, Davis – Larry N. Vanderhoef, Chancellor

University of California, Irvine – Michael V. Drake, Chancellor

University of California, Los Angeles – Gene Block, Chancellor

University of California, San Diego – Marye Anne Fox, Chancellor

University of Chicago – Robert J. Zimmer, President

University of Illinois at Urbana-Champaign – Richard Herman, Chancellor

University of Iowa – Sally K. Mason, President

University of Maryland – C.D. Mote, Jr., President

University of Michigan – Mary Sue Coleman, President

University of Minnesota – Robert Bruininks, President

University of North Carolina, Chapel Hill – James Moeser, Chancellor

University of Notre Dame – John I. Jenkins, C.S.C., President

University of Pennsylvania – Amy Gutmann, President

University of Pittsburgh – Mark A. Nordenberg, Chancellor

University of Southern California – Steven B. Sample, President

University of Texas, Austin – William Powers, Jr., President

University of Virginia – John T. Casteen III, President

University of Wisconsin-Madison – John D. Wiley, Chancellor

Virginia Polytechnic Institute and State University – Charles W. Steger, President

Wellesley College – Kim Bottomly, President

Yale University – Richard C. Levin, President

Academy Meetings

Old Mission Point, 2005. Warmer temperatures lead to reduced ice cover on the Great Lakes, evaporation of the water during the winter, and lower water levels in the lakes. Photograph by Todd Marsee, Michigan Sea Grant Archvies.

Energy and Climate Change

Rosina M. Bierbaum, William K. Reilly, and Richard L. Revesz
Introduction by Richard A. Meserve

This panel discussion was given at the 1916th Stated Meeting, held at the House of the Academy in Cambridge on October 7, 2007.

Richard A. Meserve

Richard A. Meserve is President of the Carnegie Institution of Washington and former Chairman of the U.S. Nuclear Regulatory Commission. He has been a Fellow of the American Academy of Arts and Sciences since 1994.

We have an opportunity this morning to have a far-reaching discussion about climate change with three extremely knowledgeable individuals. My role is to set the stage for them by laying out a few facts.

Figure 1 shows the exponential growth in world energy usage from 1850 to 2000. That growth will extend into the future; energy consumption is expected to increase by as much as 50 percent over the next 25 years, with disproportionate growth in the developing world. The different wedges in the figure indicate the various sources of energy. Fossil fuels meet 80 percent or so of energy demand; an additional 10 percent is derived from biomass. Because we are burning biomass at a rate faster than replenishment, it too is adding a carbon burden to the atmosphere.

Not surprisingly, as shown in Figure 2, the growth in energy usage resulted in an enormous parallel increase in global carbon dioxide emissions. This has caused, of course, increased concentrations of carbon dioxide in the atmosphere. In Figure 3, we see the concentrations of carbon dioxide in the atmosphere as measured in Hawaii from 1960 to the present. CO_2 concentrations have increased from about 280 parts per million (ppm) in the pre-Industrial period to 380 ppm or so today. The annual oscillation in the figure arises from the fact that most of the landmass on Earth is in the northern hemisphere; we see a downward cycle in the spring as photosynthesis takes carbon dioxide out of the atmosphere, and a corresponding increase in the fall.

What does all this mean? Everyone has heard about global warming. Figure 4 shows the global average temperatures from 1600 to 2000 and then a projection into the future. Scientists have developed several different but generally consistent ways to estimate global temperatures in the past. The data show a slight increase up to the present. The gray area shows the range of estimates for the future based on various scenarios involving economic growth and energy supply. The estimates are from the Intergovernmental Panel on Climate Change, a world consensus body that is studying the climate change problem. They show a stark increase above the historical baseline.

Climate change will have many effects beyond temperature change. Unfortunately, many of these effects are now already being observed.

The range of estimates for the future is broad: from the relatively small increase of two degrees at the low end up to much higher average temperatures at the upper end. Unfortunately, experience suggests that we are moving toward the upper end of the range rather than the lower end. And although these numbers may not seem large, it must be remembered that these are global average temperatures. The temperature increases are much larger at high latitudes than they are at low latitudes. So relatively small changes in the global average can mean very large changes at high latitudes.

Climate change will have many effects beyond temperature change. Unfortunately, many of these effects are now already being observed. No one can say whether a particular hurricane, for example, is the result of climate change. But one expects that the average hurricane will become more violent, and we are starting to see that. All over the globe, glaciers, ice caps, and sea ice are melting. This past summer the sea in the northern latitudes was as open as it has been in recorded history.

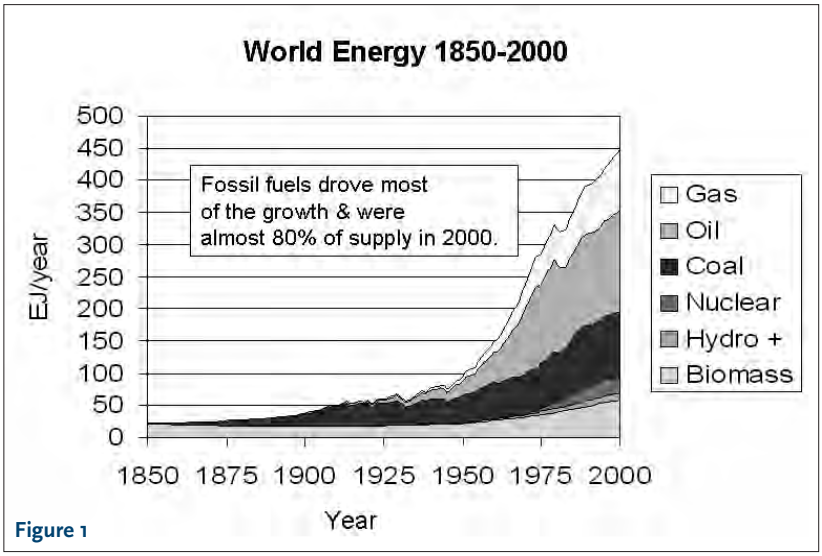


Figure 1

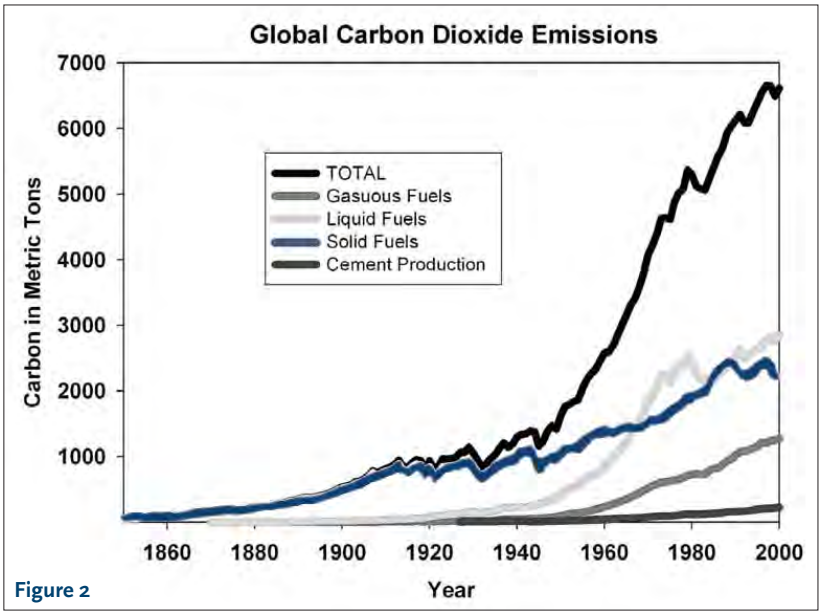


Figure 2

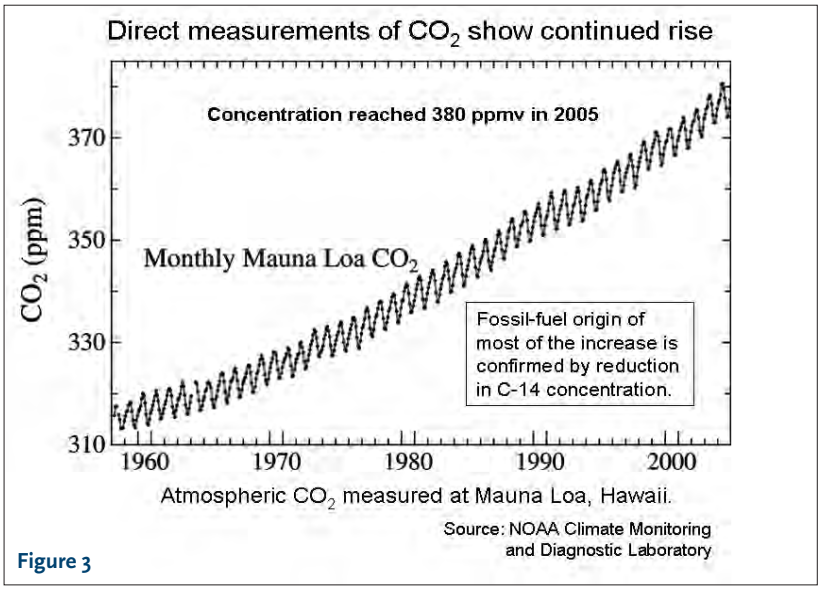


Figure 3

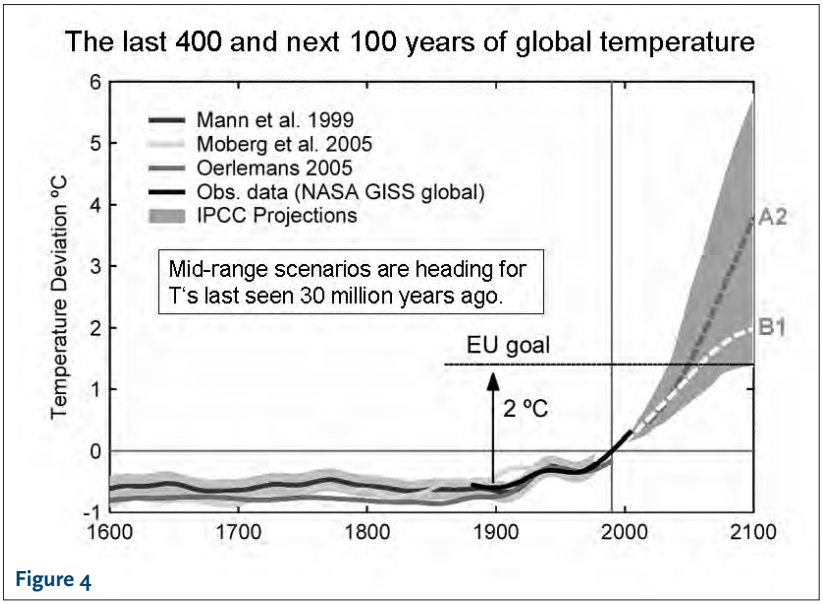


Figure 4

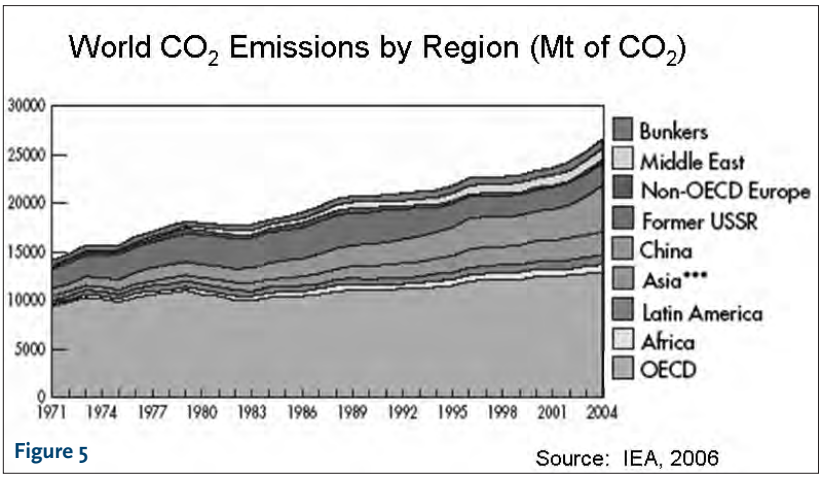


Figure 5

Source: IEA, 2006

CO_2 Data

	CO_2 Emissions (Mt of CO_2)	Population (million)	CO_2/Pop (t CO_2/capita)	GDP (billion 2000$)	CO_2/GDP (kg CO_2/2000$)
World	26583	6352	4.18	35025	0.76
China	4769	1303	3.66	1904	2.50
India	1102	1080	1.02	581	1.90
United States	5800	294	19.73	10704	0.54
OECD	12911	1164	11.09	27698	0.47

Source: IEA, 2006

Figure 6

Heat stress to crops and people is another problem. At the same time, changing patterns of rainfall will have profound effects on agriculture. The projections show that the droughts plaguing Africa will grow worse. And we can expect outbreaks of agricultural pests because they will survive future winters without the cold weather to kill them.

We will also experience increased burdens of infectious diseases as tropical vectors move north. In the United States, we are already starting to see diseases that we have previously considered tropical diseases. Climate change is threatening biodiversity as well. The changes in temperature are occurring so fast that species cannot move northward or to higher altitudes rapidly enough. They may not find niches with appropriate temperature and other conditions that they need to survive. So one expects enormous reductions in the number of species that will survive through the next century.

Finally, there is the acidification of the oceans. With increased concentrations of carbon dioxide in the atmosphere, more carbon dioxide will dissolve in the seas, producing carbonic acid. Acidification will have an impact on the many species that take calcium carbonate from sea water and use it to build shells or skeletons. We have already observed changes in the pH of the ocean. A group of 25 oceanographers published a paper last week projecting that, by the middle of the twenty-first century, the surfaces of the world's oceans will violate the EPA's water quality standard for pH.

Climate change is a severe challenge that no one country can solve. Figure 5 shows world CO_2 emissions by region from 1970 to 2004. As China and Asia grow economically, their demand for energy will increase and their emissions will go up.

In Figure 6 we have data from the International Energy Agency. Let me draw your attention to the third column, which shows estimates of the releases of CO_2 per capita. The United States has considerably larger CO_2 emissions per capita than any other country on this chart and China has about five times less per-capita emissions of CO_2 than we do. The Chinese can legitimately make the argument that they have the right to emit more. They can claim that they need more energy for their own economic growth.

But if countries at the low end use more carbon, the earth will become unsustainable for all of us.

The fifth column reflects an additional complication: the tons of CO_2 per dollar of gross domestic product. China is far less efficient in its use of carbon than we are. So at the same time that the Chinese are expanding their usage of fossil fuels, they are not doing it in an efficient manner, which aggravates the problem.

Let me return to Figure 1 and flag one additional issue that deserves to be on the table: the increase, from 1925 to the present, in the size of the wedge from oil. Beyond the climate change problem, the world's dependence on petroleum creates the special problem of energy security. It is hard to beat gasoline as a transportation fuel because of its high energy density. Yet, as we see in Figure 7, about 60 percent of the world's oil supply comes from the Middle East, the former USSR, and Africa. So for reasons completely independent of climate change, we need to be concerned about dependence on oil from unstable areas, in particular from countries who might use oil as a tool for international influence.

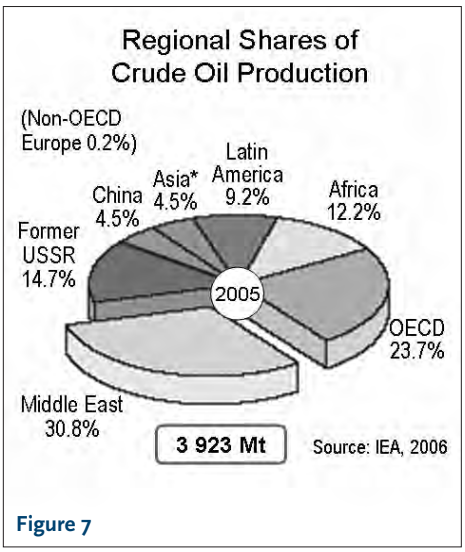


Figure 7

My comments merely set the stage for today's discussion. I hope that our three speakers this morning will reveal a path out of the dilemma in which we find ourselves.

Rosina M. Bierbaum

Rosina M. Bierbaum is Professor and Dean of the School of Natural Resources and Environment at the University of Michigan. She was elected to the American Academy of Arts and Sciences in 2007.

Time is short, both for my presentation and for humanity to confront this problem. The range of temperatures that Dick showed for the next century, up to 6 degrees Celsius, or 11 degrees Fahrenheit, is a phenomenal increase to occur in 100 years, which is a geological blink of an eye. So I want to start by saying that we need to begin thinking about climate change in a different way. It is certainly "a matter of degrees," as depicted by the thermometer, but we also have to think about climate change as the "degrees" or composite of environmental insults, including habitat fragmentation, biodiversity loss, pollution, and coastal erosion. We must consider the impact of all these interacting problems simultaneously, and try to solve them together, because by addressing just one problem, we may unwittingly create or exacerbate another.

We also need to think about climate change in terms of "degrees" of latitude and longitude. Where you live on the planet determines how climate change will feel to you. It also determines what resources and capability you have – economic, scientific, and technological – in order to address those changes. We, as a society, have spent a lot of time studying climate change as a matter of degrees of temperature, and far too little time understanding composite stresses and regional impacts.

My take-home messages are four points. First, the degrees of warming matter. Mitigation will make a difference: the more we can control and slow the increase in temperature, the better the possibilities for coping with the changes. Second, we are already committed to further climate changes. Temperatures have already increased 0.8 degrees Celsius, and another 0.4 to 0.5 degrees are in the works from greenhouse gases already emitted. Significant change is under way. The rate and magnitude of these changes make achieving the Millennium Development Goals, which were set by the United Nations in 2000, much more complicated. Third, it is not just the average changes that are of concern, but how climate change affects the vulnerability of particular regions, concomitant with multiple stresses, and the manifestation of extreme events (heat waves, floods, droughts, and hurricanes). These impacts cause great economic and human pain. Fourth, to effectively tackle climate change, I would argue for a portfolio approach. We need mitigation – that is, to reduce the emissions of greenhouse gases and slow the rate of temperature increase – but we also need adaptation to cope with the changes already under way and the impacts that are in store.

We also have to think about climate change as the "degrees" or composite of environmental insults, including habitat fragmentation, biodiversity loss, pollution, and coastal erosion.

Dick showed us that the temperatures have already increased 0.8 degrees above pre-Industrial levels. Mountain glaciers are already disappearing. As the average temperature rises to about a degree and a half, we will start seeing more extensive damage to coral reefs. As the average temperature rises to two and a half degrees, another 2 billion people will likely experience water shortages, and between 20 and 40 percent of the world's species will be at risk of disappearing. At three and a half degrees, all sectors of society across the globe are projected to be experiencing significant impacts. And remember that fully half of the projected range of tem-

Climate change will impact all sectors and regions. Source: OSTP, 2000

perature increases that Dick showed us for the next century is above this level. So the odds of going beyond three and a half degrees are very high, unless immediate reductions in greenhouse gas emissions begin.

What happens as temperatures increase? The water cycle of the planet speeds up, which increases precipitation and raises the sea level, both from melting mountain glaciers and from thermal expansion of water. Those changes in temperature and the hydrological cycle alter the ideal range where species live and flourish. They certainly change the availability and quality of water for our crops and forests, the sea level at our coasts, and the integrity of our ecosystems as a shifting climate map moves over them and the parts that swim, crawl, and fly try to keep up with the changes. The resultant heat waves and change in distribution and extent of disease vectors also affect human health (see illustration above).

Certainly, we have studied the effects of climate change to some extent but we have tended to do so sector by sector. Unfortunately, climate change is occurring simultaneously to all sectors. Further, we have not analyzed to any great degree how climate change will affect the livability of our communities, or our ability to provide energy services, or the impact on commerce and trade. I would argue that we best get on with understanding the character and magnitude of changes to our ecological, economic, and societal systems.

I had the honor of cochairing a United Nations report that came out earlier this year entitled *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable*. "Avoiding the unmanageable" means trying to mitigate climate change or reduce emissions, and "managing the unavoidable" means trying to cope with the harm. We concluded that most impacts of climate change will be negative, especially for the poorest and most vulnerable nations. Achieving the Millennium Development Goals will be difficult because climate change will affect all resources in all regions. Our city, state, national, and international institutions are ill-prepared to cope with these changes, so we need to enhance our preparedness. Both mitigation and adaptation are needed: mitigation will not work alone because it is too late to avoid substantial climate change; adaptation alone will not work because adaptation measures become more costly and less effective as the magnitude of the changes to which one is trying to adapt increases.

The Millennium Development Goals (listed at right), which the world pledged to meet, address poverty, education, equality, childcare, maternal health, disease, environmental sustainability, and development. At first blush, it might appear that only number seven, "Ensure environmental sustainability," is linked to climate change. But, as agricultural lands shift, water availability changes, and disease vectors move, our ability to provide food, improve health, provide clean water, and sustain natural resources will be degraded. As climate changes, the baseline against which we intended to measure progress on these goals shifts, and so climate change becomes absolutely central to goals one, four, five, seven, and eight. However, all the Millennium Development Goals will become difficult to achieve as climate changes because economic, ecological, and sociopolitical stability are inextricably interlinked.

Where you live on the planet determines how climate change will feel to you. It also determines what resources and capability you have – economic, scientific, and technological – in order to address those changes.

Millennium Development Goals

1. Eradicate Extreme Poverty and Hunger
2. Achieve Universal Primary Education
3. Promote Gender Equality and Empower Women
4. Reduce Child Mortality
5. Improve Maternal Health
6. Combat HIV/AIDS, Malaria, and Other Diseases
7. Ensure Environmental Sustainability
8. Develop a Global Partnership for Development

I mentioned that we need to understand regional impacts and the interaction of multiple stresses with climate change. To give you an example, the map on the left in Figure 1 displays ozone concentrations in the Eastern United States with today's climate and air pollution. The map on the right shows ozone concentrations with the climate and emissions projected for 2050. Note that there could be increases in ozone levels of more than 10 percent across much of the North-

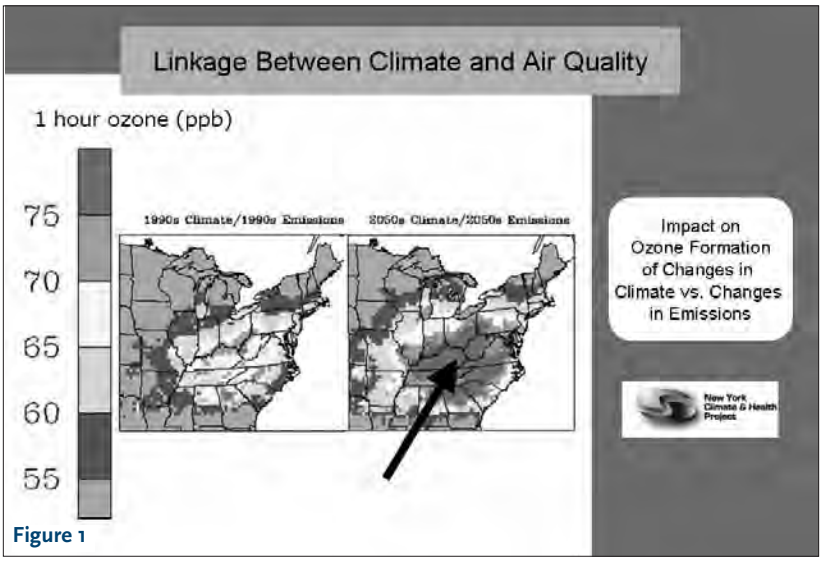


Figure 1

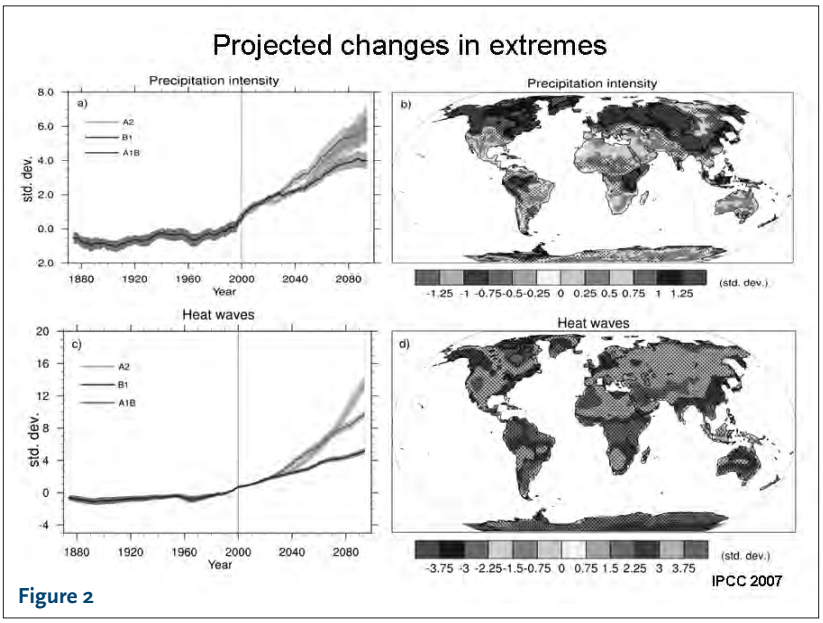


Figure 2

east (indicated by the arrow). If we do not think about how climate change and air quality interact, or more specifically how warmer temperatures enhance smog formation, we might not be able to achieve the standards we have set to protect the health of the most sensitive populations.

Understanding how climate change will impact extreme events is a high priority. Extreme events are increasing, and the human pain and economic cost are enormous. We do not handle droughts, floods, heat waves, and hurricanes well now, and, as Dick said, more are in store in the future. The upper panels in Figure 2 show the change in precipitation intensity over time. Such downpours cause floods, erode our soils, wash pollutants into our waterways, and damage crops. Rainfall intensity has already increased, and by the end of the next century, it is projected to increase greatly in many parts of the world. In the Midwest, where I live, we have already experienced a doubling in intense precipitation events from 1950 to now, and we expect that they will double again over the course of the next century.

The bottom panels in Figure 2 show the change in heat waves, which have increased slightly in recent decades. But we are headed toward a huge increase. The heat wave in 2003 in Europe, which killed 35,000 people in a rich part of the world, could become the norm as frequently as one out of every five years. Clearly, we have to learn to adapt to such dramatic increases in extreme heat and extreme rainfall. In fact, worldwide weather-related disasters in 2005 cost $375 billion, a third of a trillion dollars. That kind of cost will continue to increase, and surveillance, preparation, and response strategies are necessary in order to cope.

Even as this challenge is growing, adaptation research is lagging. A National Research Council Report (NRC) from September 2007 shows that while we are making some progress in understanding the physical climate system, we are losing the capacity to observe it, principally via satellites. Of the $1.7 billion that we spend on climate research, only $30 million is currently spent on understanding human dimensions – clearly incommensurate – and the NRC warned that we are not making progress in understanding vulnerability to climate change and its potential impacts on humans, conducting risk analysis, or understanding what stakeholders want from science to aid decisionmaking.

It is essential that adaptation options be developed rapidly. The list below is an example of some adaptation needs that came out of the First National Summit on Coping with Climate Change, held at the University of Michigan's School of Natural Resources and Environment in May 2007. Adaptation options can include wise management, new technology, changed institutions, monitoring, and research and development. For example, management of natural resources could be designed to be "robust" over bigger spatial and longer temporal scales. New design criteria may be needed for levees, reservoirs, and dams. Species preservation may require active facilitation of migration or "banking" of genetic material.

Adaptation options include:

- Prioritize Lands to Preserve
- Design Migration Corridors for Species
- Create Infrastructure to Withstand New "Extremes"
- Link Reservoirs to Enhance Supply
- Seed Banks, Mass Propagation Techniques
- Create Emergency Response Plans
- Design Early Warning Alert Systems/ Surveillance

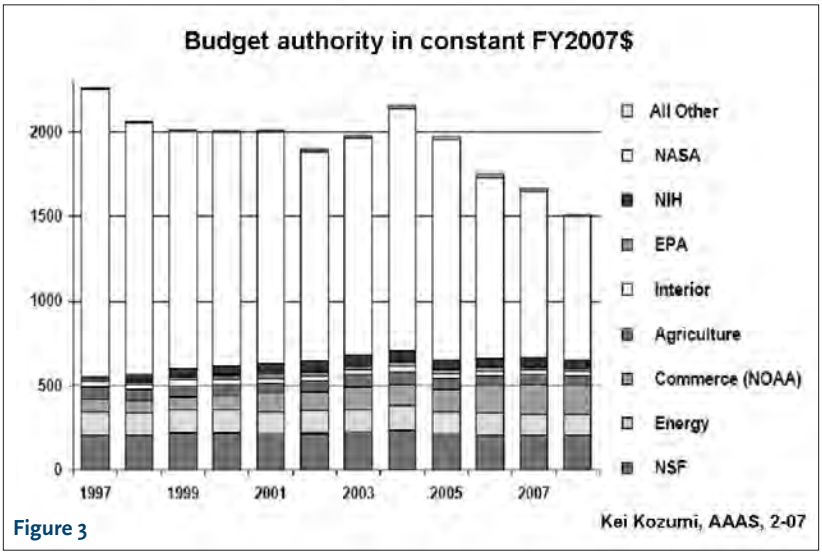


Figure 3

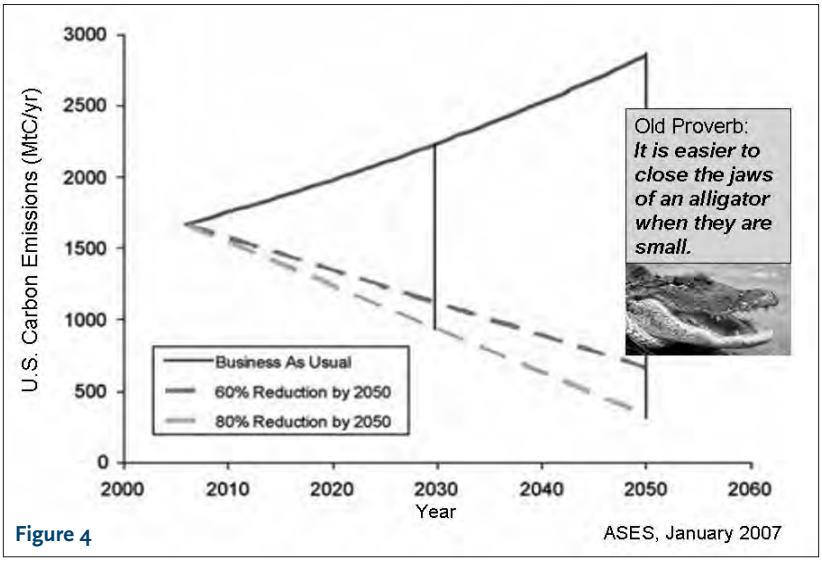


Figure 4

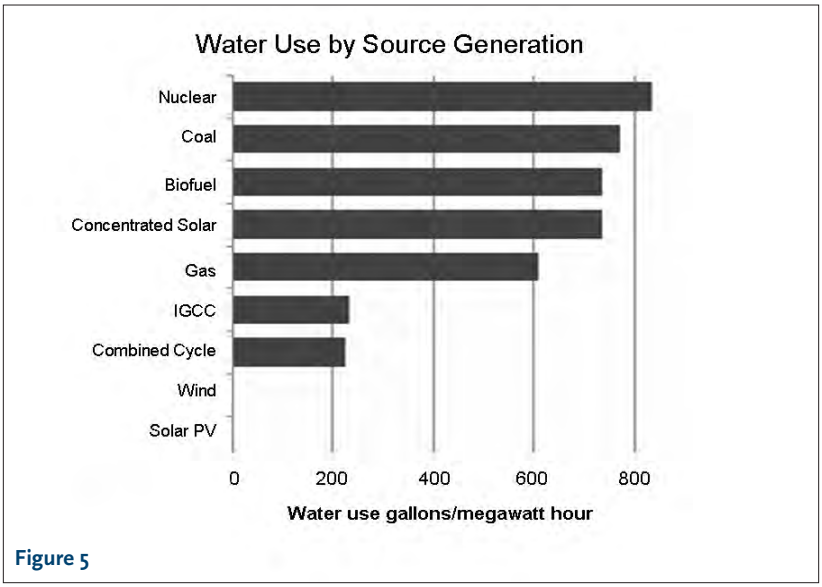


Figure 5

The degrees of warming matter. Mitigation will make a difference: the more we can control and slow the increase in temperature, the better the possibilities for coping with the changes.

This country also needs to conduct Integrated Assessments that not only synthesize the available scientific and technological information, but also identify near-term actions that make sense to implement, while also laying out short-term and long-term strategies and research needs. The United States has not published an integrated national report since the first National Assessment mandated by Congress was published in 2000. And, even as these issues become more pressing, the federal budget for this work is declining. It was $2.5 billion at its peak in 1997; it is down to $1.5 billion now. If you think about ecological impacts and infrastructure planning, the agencies that need to be involved in addressing these issues have extremely modest budgets to do so. In Figure 3, the slivers representing the Environmental Protection Agency and the departments of Agriculture, Energy, and Interior are incommensurate with the task.

Potentially good news is on the horizon, though. A memorandum from the Office of Management and Budget and the Office of Science and Technology Policy outlined the President's FY'09 priorities to the Federal agencies. It states: "Agencies should continue to make investments to improve our ability to observe, model, assess, and adapt to impacts of climate change, particularly on a regional scale, and to assure the availability of critical long-term climate data." So as agencies put their budgets together and submit them to Congress in February 2008, they should reflect these priorities, and I hope both Congress and the community will insure that they do.

On the mitigation side, or the energy technology side, things are not much better. Energy research peaked at about $6.5 billion, and we are down to just a little bit above

$2 billion. So what we are spending on all of climate science and all of energy research amounts to less than $4 billion a year. This drop in funding is happening worldwide, too. A 2006 Organization for Economic Cooperation and Development report said that the world public funding for energy has dropped from about $11 billion to $8.3 billion, and private investment in energy has dropped from about $9 billion to $4.2 billion. Yet if you look at the prodigious growth in energy supply that will occur in developing countries, there are going to be hundreds of billions of dollars in infrastructure built in the coming decades. I would argue that with this kind of investment, the United States is certainly not positioning itself to capture that new energy technology supply market. These expenditures are simply incommensurate with the task.

If we want to get down to the two to three degrees that Dick mentioned, this is what the United States would have to do to contribute its share. Figure 4 shows our "business as usual" curve. We would have to be on one of these two curves to head down, by about 2050, to a 60 or 80 percent reduction – our share of holding average temperature increase at two to three degrees. The Senate bills that are appearing – the McCain-Lieberman, the Kerry-Snow, the Saunders-Boxer, the Bingham-Specter, and the Lieberman-Warner – would all put the United States in this range, which is quite phenomenal. We should pay attention to the old proverb that it is easier to close the jaws of an alligator when they are small – and begin to make progress now.

But as clean energy solutions are sought, we have to be cognizant of the intersections between energy choices and natural resources. This is an area that has received very little attention. Figure 5 shows water use by source, in gallons per megawatt hour. Notice that biofuels, coal, nuclear, and concentrated solar all use a lot of water per megawatt hour. And just yesterday, a new Fellow of the Academy and my former boss, Jerry Melillo, reminded me that biofuels production might also lead to massive nitrogen fertilizer use that could then contribute to runoff, eutrophication of our water bodies, acid rain, etc. So there are "devils in the details" of mitigation and adaptation options that we need to consider together.

However, we can produce wise integrated mitigation and adaptation strategies. For example, sustainable land and water use policies serve multiple purposes – they are vital for agriculture, forestry, energy production, and biodiversity preservation. Renewable energy sources can be new income streams for communities that are currently importing and paying for oil, coal, or gas. Building efficient and healthy buildings that can withstand increasing floods and storm surges is a win-win.

To conclude, the past is not prologue. Basing the management and planning of energy and natural resources on the climate of the last hundred years is wrong. Adaptive management will be needed in all sectors, in all regions, to cope with changing averages, extremes, and composite stresses. Our current investment is simply incommensurate with the urgency of the problem. We need integrated science assessments and serious research development and deployment in both mitigation and adaptation.

Our generation is leaving the next generation a great challenge: sustainable management of our ever-changing planet. In order to give the next generation a chance to achieve this, we must rapidly stem the rate of growth of greenhouse gas emissions into the atmosphere, principally from energy use, and learn to cope with the changes already under way in our lifetime.

William K. Reilly

William K. Reilly is Senior Advisor to TPG Capital, Founding Partner of Aqua International Partners, and former Administrator of the U.S. Environmental Protection Agency. He was elected to the American Academy of Arts and Sciences in 2007.

I have, I think, a hopeful message this morning. One of the more encouraging developments of the past year has been the commitment by a number of our leading corporations to public policies regulating carbon dioxide in the United States. This commitment has been most notable in the 13 companies and nonprofit organizations that form the United States Climate Action Partnership. They include DuPont, Pacific Gas and Electric, Johnson and Johnson, Duke Power, General Electric, and others. This group has ambitious goals.

One of the more encouraging developments of the past year has been the commitment by a number of our leading corporations to public policies regulating carbon dioxide in the United States.

Now, why would a company commit to carbon regulation? I think of my own association with the DuPont Company, on whose board I have served as Chairman of the Environmental Policy Committee since 1993. DuPont underwent a transformation when they discovered that chlorofluorocarbons, a product that generated $800 million in rev-

enue, contribute to upper atmospheric ozone depletion. It was a stunning development for a science-based company that had considered itself responsible and mindful of the public good. This realization sensitized the company to other aspects of its operations and how those aspects related to the climate. The company changed drastically. Ed Woollard, the chairman at that time, began to refer to himself as the Chief Environmental Officer, CEO; and the company has, since 1990, reduced its greenhouse gas emissions by 72 percent. In the process, it has saved $3 billion in energy costs and has begun to transform itself from a chemical to a biological company, producing seeds that are designed to withstand droughts and lower frost intervals and generating other products, like non-fossil fuels that help us adapt to climate change.

Conoco Philips, another company on whose board I have served for a lesser period of time, recently became the first U.S. oil company to support the United States Climate Action Partnership. In that case, the decision rested upon two judgments. First, the Chief Executive Officer, Jim Mulva, and the senior management came to believe in the science that Rosina just presented. That belief, together with a sense that if the science was correct and the country and the world were headed in the direction it suggested, prompted the company to undertake to transform itself from an oil company into an energy company. It also recognized that profound new public policies were likely to impact the economic sector in which they worked, and that those companies that embraced progressive public policies earlier would be more likely to be taken seriously in the design of those policies.

One of the most notable responses to the company's promise to support California's new low-carbon energy commitment came the day after the company announced it would support the partnership, when the governor of California called the chairman and invited him to help design the low-carbon fuel standard for the state. This task is going to be highly complex, but it seems it will bear fruit for the company. Company insiders still refer, however, to CO_2 elimination as "demand destruction" with respect to its product, oil and gas. And obviously that presents particular challenges to an oil- and gas-producing company.

I would like to turn to a deal with which I have been extensively involved: the acquisition of Texas Utilities Company by TPG Capital, KKR, and to a lesser extent, Goldman Sachs. About a year ago, Henry Kravis and David Bonderman went to Texas to propose this deal to John Wilder, the chairman of Texas Utilities. The proposal was to acquire and take private a public utility, the largest electricity-generating company in Texas, with a 37 percent market share in the fastest growing electricity market in the United States. It also had some $11 billion in revenues and $2.6 billion in net income, with a share price that increased from $5 to about $60 over the last four or five years.

What I think it means to China is we will not let the lights go dim and the air conditioners go off. We will meet demand, but we will do it in a much more moderate and responsible way.

However, a great deal of anger has been directed at Texas Utilities. Texans, who had been promised reductions in their rates as a result of deregulation, have in fact seen a twofold increase in rates. Gas prices during the period had gone up fourfold, which explains the rate hikes that angered members of the Texas legislature and the ratepayers. Environmentalists despised the company, and we resolved that if we were to go ahead and make this $45 billion investment – the largest private equity investment ever made at that time – we would have to have the active support of the environmental community. So we spent several weeks looking at all of the opportunities to improve the environmental performance of a company of this sort. Through numerous conference calls, many of those with people I did not know, we came up with a number of proposals, and it fell to me to oversee the negotiation with the environmentalists.

I selected two environmental organizations. Obviously we wanted two, so as not to expose one to the kind of criticism that a deal like this might entail. I have often been asked why I chose the ones I did: Environmental Defense (ED) and Natural Resources Defense Council (NRDC). Environmental Defense is an environmental group that does deals. They did deals with me when I was Administrator of the EPA, most noticeably one in which they insisted on a cap on sulfur dioxides in the United States, a permanent cap in the Clean Air Act, in exchange for their support of the proposed bill. They and I, on behalf of the first Bush administration, agreed to that compromise one evening, and Fred Krupp, head of Environmental Defense, kept his word to support our bill.

Fred had a representative in Texas who was not particularly popular with the energy sector there, a man named Jim Marston. He had referred to TXU CEO John Wilder as the Jeffrey Skilling of the electricity business. So there was a history of severe animosity. But since ED had made its campaign against TXU's proposed expansion of coal-fired power a high priority, and had been handing out fliers in the legislature and running television ads and the rest, they were the logical people to deal with. Natural Resources Defense Council is also a very effective and respected organization, particularly with respect to climate change, and so I also brought David Hawkins of NRDC, another longtime friend and colleague, into the deal.

The most notable problem was how to meet Texas's growing capacity need in an environmentally responsible way – without increasing carbon dioxide emissions. Texas, by the way, is first in the Union in carbon dioxide emissions. When I mentioned this to one Texas legislator as the nature of the problem, he said with enthusiasm, "Yes," and I realized I had to change my pitch.

One of the things we looked at was whether to build Integrated Gasification Combined Cycle (IGCC) plants to address the carbon dioxide problem. Gasification, contrary to some perceptions, does not itself involve the capture of carbon dioxide. It involves the generation of gases that are more readily amenable to capture, transport, and sequestration when the appropriate technology and infrastructure are in place. I do not mean to demean IGCC, but we looked at the economics of gasification carefully, and in a deregu-

lated state like Texas, where one cannot simply pass the cost onto the ratepayer with the agreement of the regulator, economic competitiveness is fundamental. The technology providers do not offer warranties either for the cost of the facilities or for the reliability, neither of which have yet been adequately demonstrated.

What commitments did we make? I brought Jim Marston to San Francisco. We sat down at 7 o'clock in the morning. *The New York Times*, in a front page story, later reported on what we had for breakfast at that conversation. And by the way, just to give you a sense of how strong the feelings were on this, when I asked David Hawkins of NRDC, without mentioning Texas Utilities, about his views on coal, he said, "If you want to understand how bad it can get, look at the expansion plan of Texas Utilities. They're going to build 11 new coal-fired power plants in Texas, and 3 more in the deregulated states of Virginia, Maryland, and Pennsylvania. It's the *Mein Kampf* of the carbon wars." I went back to my partners and said, "I think this could be harder than we thought."

At any rate, David was one of the people who went through the long negotiation with me. We agreed to scrap all 3 of the coal-fired power plants that had been contemplated in the 3 deregulated energy states, and 8 of the 11 coal-fired power plants planned in Texas, in return for the environmentalists' agreement to support the remaining 3. We promised a significant reduction of SO_2, NO_x, and mercury in all 18 existing Texas Utilities facilities. And we assured the environmental community that the company would embrace carbon regulation and apply for membership in the United States Climate Action Partnership. This, I might add, stunned the Texas congressional delegation, and just a few weeks later, Conoco Philips, another major Texas energy company, also committed to join the partnership. So in terms of the long-term political impact, the deal may turn out to be somewhat significant as well.

We also committed to spend $400 million on energy efficiency to bring down the CO_2 growth rate and energy use over the next five years, and to make TXU the largest purchaser of wind power in the country. Texas is particularly well suited for wind and already leads the Union in production of wind power. TXU's commitment to purchase large amounts of wind power made it possible to finance more wind power in the state by guaranteeing the offtake. Finally, we committed never to build another conventional pulverized coal-fired power plant. We are betting on technology that relies on noncarbon or carbon-capture technologies to increase Texas's capacity. Texas, by the way, because of its history with enhanced oil recovery, has the pipelines and the experience of injecting CO_2. So it is one of the places where a sequestration experiment could be founded.

When major utilities and large private equity financiers engage the climate issue in a significant and innovative way, the nation's economic sector has entered a new and promising era.

In explaining this plan to members of Congress, we were largely embraced because several members of Congress had been considering punitive measures against new coal-fired power plants. One hundred fifty coal-fired power plants, by the way, are now under consideration for permits in the United States. Among the members of Congress whom I briefed, only Senator Kerry was negative. He asked me, "Bill, what does this mean for China?" In fact, the Chinese have closely followed our experience. But whereas Texas has a 2.3 percent growth rate in electricity demand, the Chinese two years ago had a 16 percent growth rate. The Chinese added 93,000 megawatts of coal-fired power to their capacity last year, significantly more than one new coal-fired power plant a week.

What I think it means to China is we will not let the lights go dim and the air conditioners go off. We will meet demand, but we will do it in a much more moderate and responsible way. We will be attentive to our carbon dioxide impacts, and we will try to bring them down. We will try to do it in an economically acceptable and intelligent way, but we are committed to do it. The net impact of all of these measures is to reduce the carbon dioxide emissions that otherwise would have been associated annually with the expansion of Texas Utilities by 55 million tons of carbon dioxide.

Based upon telephone calls I have received, this deal has had a large impact on two groups of people. One group consists of environmentalists, many of whom have called me to ask, "Why didn't you call me?" to which the answer was, "Well, I read your website, and it looked like there was no way you could ever agree to any coal-fired power." And yet, a few weeks after our deal, the Sierra Club made an agreement with Kansas City Power and Light to do something similar, though on a somewhat smaller scale. The other calls have been from power companies, particularly from AEP, the largest coal-fired power company in the country, whose CFO Holly Koeppel said, "We watched in amazement at what you did, and we want to open a dialogue with the environmentalists."

When major utilities and large private equity financiers engage the climate issue in a significant and innovative way, the nation's economic sector has entered a new and promising era. While the United States awaits enactment of serious climate policy, the private sector is displaying a new and encouraging response.

Richard L. Revesz

Richard L. Revesz is Dean and Lawrence King Professor of Law at New York University School of Law. He was elected to the American Academy of Arts and Sciences in 2007.

My talk will take off from a sentence in Rosina's presentation. She said that most impacts of climate change will be negative, especially on the poorest and most vulnerable nations. There are a number of reasons for that. Some specific problems were discussed in her presentation, but generally the reasons fall into one of three categories.

The primary beneficiaries of anything we do on climate change are likely to be future generations in developing countries.

First is differential exposure. For certain of the negative impacts, tropical areas are likely to be most affected. Second is sensitivity. Poorer countries tend to be more dependent on agriculture, and to the extent that climate change will negatively affect agriculture, they will suffer more. They also have lower levels of health and are experiencing rapid population growth. Lastly, poorer developing countries are likely to have less adaptive capacity. They may not have the infrastructure to contain rising sea levels or to deal with public health problems, or the institutional strength to deal with problems more generally.

The result is that the primary beneficiaries of anything we do on climate change are likely to be future generations in developing countries. Why future generations? As we heard earlier today, the temperature increases, which at this point have been relatively modest, are going to grow substantially over the next 50 or so years. For a lot of environmental policy, we perform economic evaluation, which has been required for federal regulations since 1981. An executive order mandates that any environmental regulation that poses costs on the economy of more than $100 million a year has to be justified in cost-benefit terms. This obviously does not apply to Congressional acts. Nonetheless, there is a strong view in the academic community that public policies should be justified by reference to their economic impacts and in terms of costs and benefits. And my view is that this requirement is actually a good thing. The only question is how you go about doing the analysis.

A problem arises when we have to figure out the benefits that accrue to future generations. The economic literature would generally discount such future benefits in light of two factors. The first is a pure rate of time preference. Essentially, you would look at this in the same way you would look at financial flows. Obviously, getting a million dollars ten years from now is not the same as getting a million dollars now. That calculation is trivial. Anyone can do it. But the question is, how do you deal with an impact on a life ten years from now or a hundred years from now versus an impact on a life now? If you use discounting at any sort of rate used in economics, impacts 100 or 500 years from now are worth virtually nothing. So we would be willing to pay almost nothing to save thousands, even millions, of lives in 100 or several hundred years.

The second component generally assumes that there should be an additional discount because future generations will be wealthier than the current generation is. The general assumption is a declining marginal utility of money – an additional dollar is worth less to someone who's wealthier than to someone who's poorer, and since we are poorer than people in the future will be, the additional dollar is worth more to us than it would be to people in the future.

Any expenditures in stopping climate change are going to be expenditures from the developed world now to benefit developing countries in the future.

This is a complicated issue, and I cannot give you the full solution. I will indicate some problems with these two components. First, the pure rate of time preference. My claim is that applying these discounting concepts to the future generation has no appeal to any plausible moral theory. I have developed this simple example, which will not answer every question, but I think will give you an idea of what I mean. Think of a world that has only two people. The first person lives from years 1 to 50, and the second from years 51 to 100. In this world there are 100 units of resources that are split between these two people. Let us also say that each of these people can transform these resources into utility in exactly the same way. These resources are not going to increase, so we only have these 100 units. The next question is, "How would you like to distribute these 100 units of resources between the two people?"

I try this exercise with my class all the time. Most people's intuition is that each person should get 50 units. But any discounting for a pure rate of time preference would give almost all the resources to the first person. Now, sometimes people say, "Well, this is a very simple world with no productive capacity, and obviously the real world works differently." But the point is that a pure rate of time preference is a pure rate of time preference, and all the other complications are just complications that are going to be dealt with eventually.

But the normal intuition suggests that there is a problem with a pure rate of time preference. The standard economic model for a pure rate of time preference is usually associated with an influential article by Kenneth Arrow. I was actually once very fortunate to discuss the problem with Arrow. I was co-teaching a course with an economist at Princeton, and Arrow was at Princeton for

a public lecture. We invited him to come to our class, where we were talking about this problem. When I posed this hypothetical to him, he was extremely generous and said, "Ricky, my theory does not work well with your example. And the fact that it doesn't work well with your example does count as an argument against my theory."

Now let us think about the point relating to the greater wealth of future generations. I have said that the primary beneficiaries of climate change policies are future generations in developing countries. As you know, the differential in GNP per capita between the developing world and the developed world is staggering. It is not plausible, during any of the time frames that we have been talking about, that developing countries are going to be wealthier than the developed world is now. So essentially, any expenditures in stopping climate change now are going to be expenditures from the developed world now to benefit developing countries in the future. And those countries in the future are going to continue to be poorer than we are now. So if one is worried about the marginal utility of additional money, this provides an argument for negative discounting. That is, we would want to send more resources that way because we will be benefiting people who are poorer in the future than we are now. Once that argument is made, though, there is usually a quick counterargument: "Look, why would we want to benefit developing countries in the future since we don't seem to be very willing to benefit developing countries in the present?" For this claim, I cite the very low levels of foreign aid from the United States and less so from the rest of the developed world.

One of the beauties of climate change policies is that they are immune from the corruption of developing countries. Anything we do in the developed world to reduce our impact would result in benefits.

I have two plausible answers to that counterargument. First, just because we have been doing badly in one area should not mean that we should use it to justify doing badly in another area. My sense – and I am not a scholar of foreign aid – is that the most plausible moral theories would suggest that we should do more than we are doing now. But leaving that aside, one of the concerns about foreign aid is the vast levels of corruption in developing countries. The claim is, "Why should we spend a lot of money to be extremely ineffective?" And a lot of foreign aid is ineffective. Empirical studies have shown that transferring money to certain African nations for health programs results in something like one cent to the dollar in actual benefits to people, and so on.

One of the beauties of climate change policies is that they are immune from the corruption of developing countries. Anything we do in the developed world to reduce our impact would result in benefits, and corrupt governments of developing countries will and can do nothing to stand in the way of those benefits actually accruing to them in the future. The question of projects that the developed world could do in developing countries is somewhat more complicated. But typically, investments in specific projects in the developing world, which are often undertaken by the private sector, are much more effective in helping the beneficiary countries than our government-to-government aid programs. So even people who are skeptical about things that we can do now to help current generations in the developing world could come to see that the situation is quite different when the question is how we can help future generations of the developing world now through the kinds of policies that this panel discussed. ■

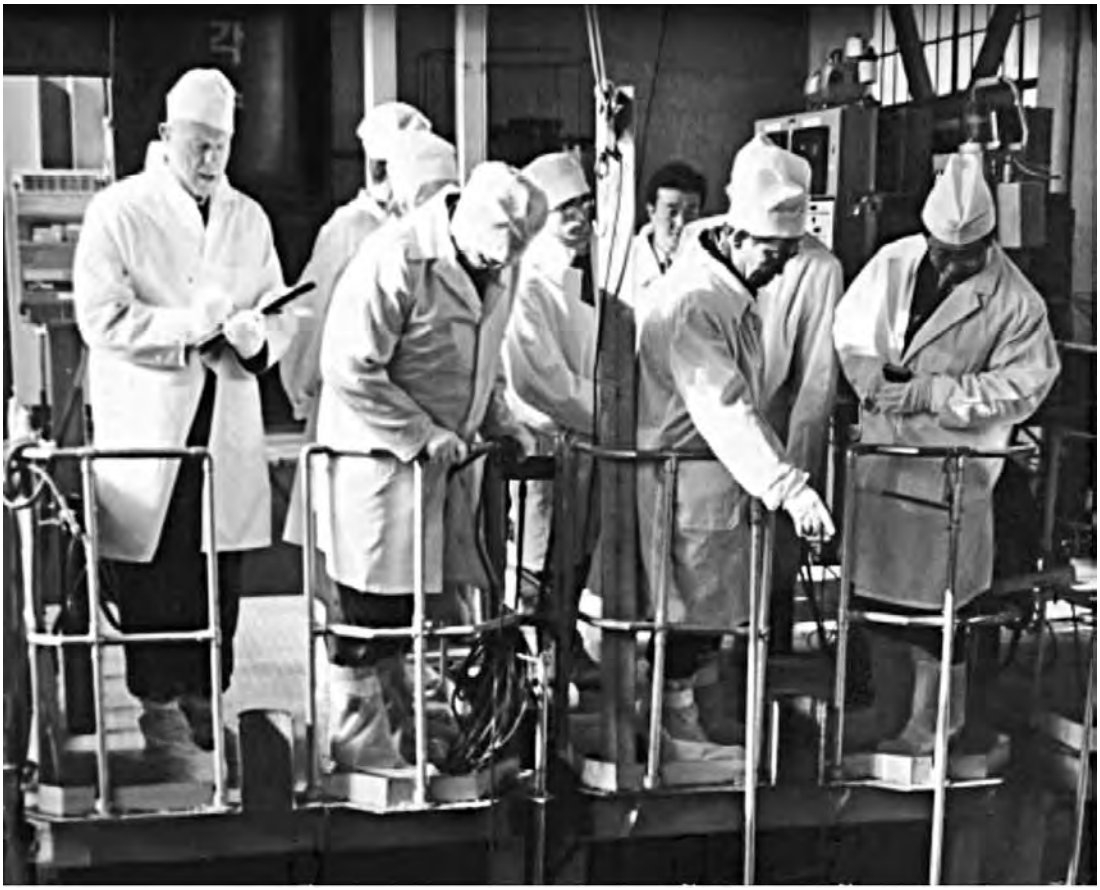
Richard Meserve (Carnegie Institution of Washington) and President Emilio Bizzi (Massachusetts Institute of Technology)

Helen Bowdoin Spaulding (Boston Foundation) and Louis W. Cabot (Cabot-Wellington, LLC)

Richard Revesz (New York University), Galit Sarfaty (Visiting Scholar), and Paul MacDonald (Visiting Scholar)

Leslie Berlowitz (American Academy) and Peter Nicholas (Boston Scientific Corporation)

Eugene Skolnikoff (Massachusetts Institute of Technology) and Nicholas Zervas (Massachusetts General Hospital)



Stanford Professors Siegfried Hecker and John Lewis with North Korean scientists at the Yongbyon Nuclear Power Plant in North Korea. Photograph courtesy of the Center for International Security and Cooperation, Stanford University.

Nuclear Power without Nuclear Proliferation?

Scott Sagan, William J. Perry, Alexei Arbatov, and Thomas Isaacs
Welcome by John L. Hennessy

This panel discussion was given at the 1917th Stated Meeting, held at Stanford University on October 15, 2007.

John L. Hennessy

John L. Hennessy is President of Stanford University. He has been a Fellow of the American Academy of Arts and Sciences since 1995.

Welcome

I am delighted to see so many of my colleagues, and it is wonderful to have such a diverse audience. There are few seminars that I go to at Stanford that include psychologists, lawyers, linguists, engineers, and historians. Bringing together such a multidisciplinary group is the mark of the American Academy, and it is one of the things we celebrate here, especially when solving challenges like the one we are going to talk about today will increasingly demand cross-disciplinary collaborations.

At Stanford, the topic of today's discussion had its roots in a conversation that I had some time ago with Scott Sagan, William Perry, and George Schultz. They came to me and said that they wanted to work on the issue of nuclear power and nuclear proliferation. Having looked at some of the data, I realized that nuclear power is perhaps the only viable short-term solution to our dependence on fossil fuel that can reach a reasonable scale quickly. I knew we had to reengage the issue of nuclear power. Nuclear power raises a number of concerns, such as licensing, safety, and waste disposal, but the towering concern is nuclear proliferation. So I am delighted to see this panel here today, and I look forward to this discussion.

Scott Sagan

Scott Sagan is Codirector of the Center for International Security and Cooperation and Professor of Political Science at Stanford University. He is also Codirector (along with Steven E. Miller) of the Academy's Global Nuclear Future Initiative.

Will it be possible to have a major expansion in the use of civilian nuclear power around the world without increasing the risk of nuclear proliferation and nuclear terrorism? The answers to this critical question will influence our environment, economy, and security for generations to come. The renaissance of interest in nuclear power around the globe has emerged, unfortunately, precisely at a time when the political regimes that have managed the spread of nuclear weapons are severely challenged. Most visibly, over the past decade, the number of countries with nuclear weapons – India, Pakistan, and North Korea – has increased; and the number of countries with suspected covert nuclear weapons programs – Iran and, as we learned this weekend, perhaps even Syria – has also increased. In addition, transnational terrorist groups have grown in size and have expressed interest in acquiring nuclear materials. In short, while nuclear power is likely to play a significant role in the global campaign to reduce global warming and produce energy security in the future, it is critical that we do not inadvertently increase the danger of nuclear weapons proliferation and nuclear terrorism.

The American Academy is launching a major initiative, designed to bring together a diverse group of technical and policy experts from the United States and abroad, to address these issues. The goal is to produce rigorous science and social science research that will clarify and inform contemporary policy debates. Today's panel inaugurates a series of panel discussions, which we hope will galvanize interest in this Academy initiative.

Before I introduce our speakers, I want to show two charts that give a visual sense of the challenge we face. Figure 1 is a representation of the number of states in the world with nuclear weapons. The slight increase and then decrease reflects Ukraine, Belarus, and Kazakhstan inheriting nuclear weapons and then returning them to Russia for eventual dismantlement; the other decrease represents South Africa getting rid of its program and its handful of nuclear weapons. That is a measure of where we are.

Will it be possible to have a major expansion in the use of civilian nuclear power around the world without increasing the risk of nuclear proliferation and nuclear terrorism?

How many states have the capability to develop nuclear weapons? This is a much more complex issue because there is no single, agreed-upon measure of a nation's latent nuclear weapons capability. This is under-

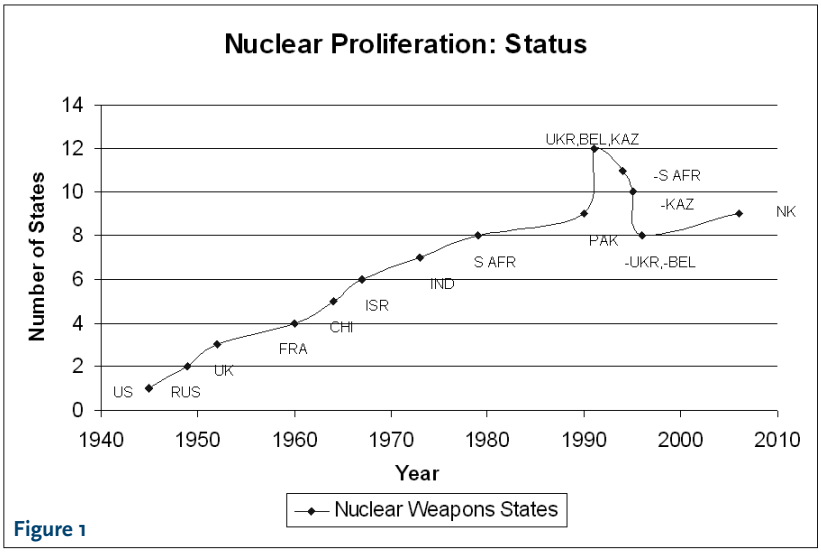


Figure 1

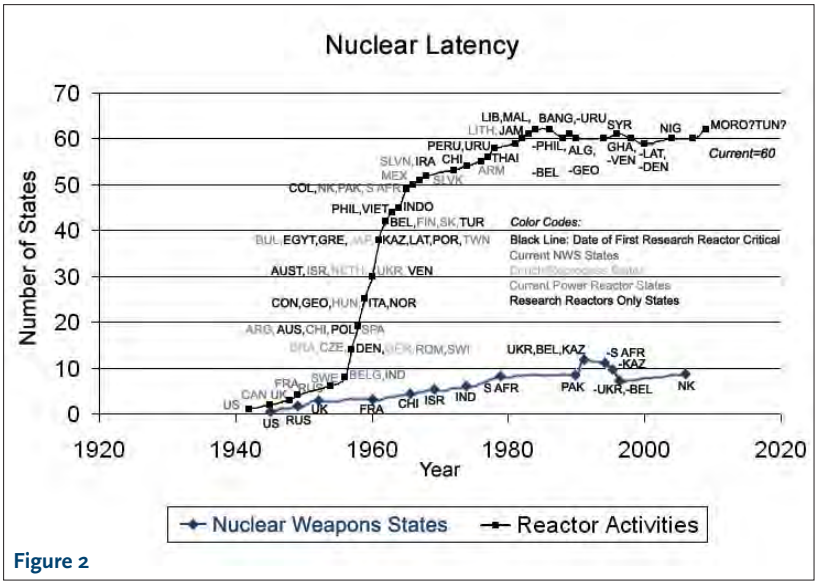


Figure 2

standable given that there are many different pathways by which one could acquire nuclear weapons, and many different technological hurdles that one has to overcome. But one factor that provides at least a minimum amount of technical knowledge and engineering experience is the operation of a research reactor. What we see in Figure 2, on the blue line, is the number, identity, and date of each state that has gone critical with a research reactor. Many of these states, as you can see by the other colors, later developed either commercial power reactors or reprocessing and enrichment capabilities. The difference between that number, now 60 and growing, and the nine nuclear weapons states is, I would argue, both a measure of the success of the Nuclear Nonproliferation Treaty regime and a measure of the challenge that we face and will continue to face as we expand nuclear power – but hopefully do not expand, and perhaps even decrease, the number of nuclear weapons states.

This meeting is dedicated to the memory of Pief Panofsky, whose death last week was a loss to both the physics and the arms control community around the world. The week before Pief died, he spoke at a CISAC workshop on nuclear power and nuclear proliferation. He warned us, using Karl Popper's metaphor that has been popularized by Nassim Taleb, to beware of black swans – namely, rare and unexpected events. Pief mentioned the possibility of another Chernobyl-scale accident, or the seizure of nuclear material in transit by a terrorist organization, or the use of a single nuclear weapon by a new proliferant. What are the effects of these black swans on our analysis? I have asked three distinguished speakers to share with us their thoughts on this topic.

William J. Perry

William J. Perry is the Michael and Barbara Berberian Professor at Stanford University, a Senior Fellow at the Hoover Institution, a Senior Fellow at the Freeman Spogli Institute for International Studies at Stanford University, and Codirector of the Preventive Defense Project at Stanford's Institute for International Studies. He served as Secretary of Defense from February 1994 to January 1997. He has been a Fellow of the American Academy of Arts and Sciences since 1989.

Two of the greatest dangers facing the world today are terrorists detonating a nuclear bomb in one of our cities and catastrophic changes in the planet's climate. A nuclear terrorist attack, of course, would not be like the holocaust we faced during the Cold War, which could have led to the extinction of civilization. But still, it would be the greatest single catastrophe we could suffer. A few months ago, the Preventative Defense Project, a research collaboration between Stanford and Harvard, held a workshop called "The Day After" to discuss what it would be like the day after a nuclear bomb went off in one of our cities. We concluded that we would have more than 100,000 casualties. But the direct and indirect economic losses would be even greater, as markets would crumble in a way that would make the collapse after 9/11 seem inconsequential. There would be political turmoil, since people would lose faith in the government's ability to protect them. That turmoil would be even greater if the target of the bomb were Washington, D.C., and a major part of our government was eliminated. The social chaos would be unimaginable. The scenario we looked at included the terrorist group announcing that it had planted

Two of the greatest dangers facing the world today are terrorists detonating a nuclear bomb in one of our cities and catastrophic changes in the planet's climate.

bombs in three other cities and would detonate one every month if certain demands were not met.

We concluded that there is no way to prevent the movement of a bomb or fissile material into an American city, to defend against such an attack, or to deter such an attack. Our only hope is to keep the terrorists from getting the bomb. And that hope diminishes as more nations produce more fissile material.

The second danger I mentioned, catastrophic changes in the planet's climate, is caused by large increases in the amount of carbon emitted into the atmosphere. Any prospect of averting this catastrophe depends on stopping the increase in carbon emissions, followed by a reversal of the emissions. We understand the programs and the policies that are necessary to accomplish that, but there is no political will to undertake the huge costs that are involved. No single action can turn around carbon emissions. Multiple actions are required on a global scale, including changes in lifestyle that reduce carbon emissions; major increases in efficiency of energy consumption, such as plug-in hybrids and green buildings; and significant increases in the use of energy sources that do not emit carbon, such as solar, wind, and nuclear power.

Many experts believe that a new generation of nuclear plants is a critical part of that solution. Even if you do not agree, it is absolutely clear that many other nations do and are already pursuing a major construction program of new nuclear plants. China is the prime example, but India will likely follow suit. The alternative program for generating more electricity in China is the large-scale construction of coal-fired generators, which would doom any attempt to reduce carbon emissions. So there is a dangerous conflict

between our need to keep nuclear bombs out of the hands of terrorists and our need to reduce carbon emissions. The global move to increase nuclear power could lead to significant increases in a terrorist's ability to access fissile material. It would not be useful, I believe, to fight nuclear power. China and India are headed that way, regardless of what we say or do. The solution must lie in establishing protocols for how nuclear plants are operated and how nuclear fuels are handled. Indeed, these protocols are desirable even if no new plants are built. But it becomes more critical as the construction of new plants accelerates. There are many alternatives but no political will to enact any of them on a global scale. I would encourage ongoing discussion on what the protocols should be.

Many experts believe that a new generation of nuclear plants is a critical part of the solution to reduce carbon emissions.

I am concerned with how to achieve the necessary political will so that an alternative has a chance of global acceptance. Getting to that political will is a major objective of *The Wall Street Journal* op-ed that I coauthored earlier this year. It is a major objective of the seminar CISAC is holding later this week. It was a major objective of the two Reykjavik meetings held at Stanford last year and of the one being held next week. And it is a major objective of the Nuclear Threat Initiative and its cochairmen, Sam Nunn and Ted Turner.

Alexei Arbatov

Alexei Arbatov is Scholar-in-Residence and Program Chair of the Nonproliferation Program at the Carnegie Moscow Center of the Carnegie Endowment for International Peace. He also heads the International Security Center in the Institute for International Economy and International Relationships at the Russian Academy of Sciences.

The title of our roundtable is "Nuclear Power without Nuclear Proliferation?" Both Scott Sagan and William Perry have described the general environment in which the response to this question has to be elaborated. Let me add that the generation of new nuclear energy technology will be much safer than the present one, from a proliferation point of view. The present and past generation of nuclear power plants was a by-product of nuclear weapons programs. But the employment and use of nuclear power plants to produce peaceful energy was a useful by-product of the development of nuclear weapons. I hope the next generation will be specifically designed for peaceful purposes and will have certain safeguards against the usage of the technology for military purposes.

However, the next generation of nuclear peaceful technologies, which is now discussed under the title Global Nuclear Energy Program (GNEP), may not reach an industrial scale for another 20 to 30 years. Somehow we have to live through the next 20 or 30 years with existing power plants, which are not safe. There are approximately 500 such power plants, with more than 1,700 tons of highly enriched uranium in various forms and more than 150 tons of weapons-grade plutonium. After Iran, at least seven or eight countries have declared their intention to go for the nuclear fuel cycle, with about 10,000 operationally deployed nuclear weapons in the existing nine nuclear weapons states. Under the best circumstances, these countries will fulfill their present obligations to reduce weapons and no new nuclear weapons states will emerge.

The next wave of proliferation will probably not be from new nuclear weapons states but rather from new non-state or sub-state organizations – in particular, nuclear terrorists.

This is the environment in which we have to make sure that proliferation does not go further. Is it possible? As in all areas of security, the answer is not yes or no. It is simply more or less possible under various circumstances. And the response is all that more important because the next wave of proliferation will probably not be from new nuclear weapons states but rather from new non-state or substate organizations – in particular, nuclear terrorists. Certainly, the proliferation of nuclear weapons and technologies to new states makes it easier for terrorists to get access to nuclear materials or nuclear weapons. These two processes have a synergistic relationship. The black market of nuclear technologies and materials, which goes together with nuclear proliferation, creates a channel through which terrorists can gain access to nuclear weapons and materials.

Is it possible to alleviate this problem? My response is no under the present circumstances, especially if things continue as they are. Moreover, if the current trends continue, the employment of nuclear explosive devices in combat, by new states or by terrorist organizations, for the first time since August 1945, will not only become more probable but almost unavoidable within the next five to ten years. How do we deal with that?

The roadmap and the menu are very well known, so I will mention just a few things.

As strange as it sounds, the way to deal with nuclear weapons, nuclear proliferation, and nuclear terrorism is to start with non-nuclear weapons – in particular, to resolve the problem created by the American ballistic missile defense program and the plan to deploy it in Europe.

First, North Korea has to return to the Nonproliferation Treaty – that is, North Korea needs to follow the South African model. South Africa created six nuclear explosive devices, but in 1992 got rid of them and entered the Nonproliferation Treaty under full safeguards. Second, we have to make sure that Iran does not follow the North Korean model – that is, Iran does not create and test nuclear weapons. Third, we have to make sure that if Pakistan's present government collapses, its nuclear weapons do not get into the hands of terrorists. These three countries need to be at the center of attention. We also need to have more efficient international atomic energy safeguards, making universal the additional protocol of 1997. We need more stringent export controls and greater physical protection, accounting, and control of nuclear materials all around the world.

Can we do this? No. Both Russia and the United States are now further away from each other in their approach to nuclear weapons and their approach to nonproliferation. If that disparity widens, we will have no chance of implementing individual efforts with respect to the three countries I mentioned, or global efforts dealing with proliferation threats in general. It is strange considering that after the end of Cold War, the great powers, United States and then Russia, indulged in a sadomasochistic effort to dismantle nuclear arms control and the nuclear arms regime, which was created during 40 years of the most difficult, most complicated, and greatest negotiations in the history of mankind. If Russia withdraws from the Intermediate-Range Nuclear Forces Treaty, as it is hinting, we will be left with only the Partial Test Ban Treaty of 1963 and the Threshold Ban of 1976. And we will be unable to stop further proliferation.

As strange as it sounds, the way to deal with nuclear weapons, nuclear proliferation, and nuclear terrorism is to start with non-nuclear weapons – in particular, to resolve the problem created by the American ballistic missile defense program and the plan to deploy it in Europe, which is now a major part of the discord in the strategic relationship between Russia and the United States. President Putin's proposal is a good beginning, but unfortunately, there is too much posturing around the issue and no real attempts to negotiate. If we are successful in resolving the ballistic missile defense issue, then all of the steps necessary for an enhanced nuclear disarmament/nonproliferation regime treaty on strategic arms – to deal with tactical nuclear weapons, and then to implement the collective efforts needed to insure nonproliferation – will be possible.

Thomas Isaacs

Thomas Isaacs is Director of Policy, Planning, and Special Studies at Lawrence Livermore National Laboratory.

I would like to discuss three questions. First, will there be a resurgence of nuclear power and what might it look like? Second, what is the impact of that potential resurgence on proliferation and will it be important? Third, is there a window of opportunity and, if so, what needs to be done?

If we look out, say, 20 years, we can be somewhat confident that there is likely to be a growth and, importantly, a spread of nuclear power plants around the world.

Will there be a resurgence of nuclear power? In the past, we have not always done well at predicting the future of nuclear power growth. So we should be somewhat cautious about our ability to predict that future. But if we look out, say, 20 years, we can be somewhat confident that there is likely to be a growth and, importantly, a spread of nuclear power plants around the world.

Why? Three reasons stand out. First, energy growth and security. Many countries in the world are rapidly developing and they will require much more energy. It is not just a matter of price but also of access to the fuels

Having a diversity of fuel options is important to a country's long-term health and security.

that one needs. Having a diversity of fuel options is important to a country's long-term health and security. Keep in mind that building a new energy source whether it is a coal-fired or a nuclear plant takes many years before that plant is operational and generations before it is able to provide a full return on investment. Second, fossil-fuel plants are extremely dependent on the price of the fuel. Those prices are unpredictable and often rising. Third, of course, is global climate change. We are just beginning to see serious attention paid to this issue. Obviously, nuclear power has a number of significant advantages in minimizing the impact of fossil fuels by contributing a larger share of electrical production.

But nuclear power does not have a free ride. First, nuclear power plants are expensive to build. Finding the financing to make it a successful venture requires both access to capital and the faith that you are going to be able to run these plants and have the fuel that you need for decades. Second, safety. When it comes to nuclear power, as is often said, a safety incident anywhere is a safety incident everywhere. Third, nuclear waste. Today, there are no operating nuclear repositories anywhere in the world for the ultimate disposal of high-level waste or the spent nuclear fuel that comes out of nuclear power plants. In this country we continue to struggle at Yucca Mountain. Fourth, as has been mentioned already by President Hennessy and many others, proliferation.

So where do we stand? There are 439 nuclear power plants operating today in 30 countries. It is interesting to note that half of them, 15 countries, have fewer than five nuclear power plants. Almost all of those plants are light-water reactors. These reactors use low-enriched uranium as fuel, meaning 3 to 5 percent of the fuel is Uranium-235, the rest is Uranium-238. Since Uranium-235 is a potential weapons usable material, we are fortunate that separated Uranium-235 does not occur in nature, so the uranium has to be enriched. The same plant that enriches the uranium could also potentially create one of the predominant weapons-usable materials, by enriching the uranium well above the 3 to 5 percent. It is important to note, however, that the enrichment plant making fuel does not produce a material that is directly usable in a nuclear weapon.

Thirty-four nuclear power plants are under construction around the world. Most are in the Far East. Worldwide, 81 have been ordered or planned, and 223 have been proposed. The most interesting statistic is that 40 countries that currently do not have nuclear power have shown some interest in developing nuclear power. They are almost all developing countries. So the growth of nuclear power is important; the spread of nuclear power is also important. Building another nuclear power plant in the United States does not change the proliferation concern. Building the first reactor in an Iran or Iraq or North Korea does.

In next 20 years, we may see small numbers of other reactor types, but the great majority will be light-water reactors. If a CEO is going to invest billions of dollars on a facility, he or she most likely will invest in technology that has already been proven, that is already licensed and running. So for the foreseeable future – that is, for the next generation – most plants will be light-water reactors, although some other types are in development.

Perhaps more interesting and important is the enrichment and reprocessing issue. As I said, weapons-usable materials do not exist in nature in directly usable form. One either has to enrich uranium, which is a difficult process, or one has to take uranium, put it in a nuclear power plant, run the power plant, pull the fuel out, and then reprocess the spent nuclear fuel (the used fuel) to remove the plutonium that has been created in the nuclear process. Plutonium is the other predominant weapons-usable material.

Fortunately, the number of countries that have uranium enrichment and reprocessing facilities is small. And the major ones are the weapons states, for obvious reasons. There are some others as well, like Japan. But the real challenge comes as we start to diversify and spread nuclear power plants. As we start to see more countries looking for energy security, not in terms of 5 or 10 years but 20 or 50 years, they are beginning to say, "Maybe I need to assure my own fuel supply. Maybe I need my own enrichment plant. Maybe if I am going to have a large nuclear infrastructure, I also want to be able to reprocess that nuclear fuel so I can get back the unused uranium and the created plutonium." Those are the concerns. We have known from the start that enrichment and reprocessing plants can make nuclear fuel but also weapons-usable material.

It is also important to know that we are not starting from zero. There are more than 250,000 metric tons of spent fuel around the world that have been in and now out of nuclear power plants. And there are hundreds of metric tons of plutonium sitting in that spent fuel. The good news is that it is self-protecting. Those spent fuel elements are highly radioactive. They are hot, big, and bulky. The bad news is that over many decades and generations, a fuel element will lose much of that self-protection and become more accessible. There are already 250 metric tons of separated commercially produced plutonium in the world, largely in the United Kingdom, France, and now in Japan, that has been reprocessed. That material is being separated faster than it is being used in nuclear power plants, and we are seeing more separated plutonium sitting in storage around the world. This is a bad trend, because the material is directly "misusable." It is also important to note that large quantities of high-enriched uranium are coming out as excess from weapons programs. That material is being blended down to low-enriched uranium so that it cannot be used for weapons but can be used for fuel. Lastly, there are 284 research reactors in 56 countries, many of which are fueled with high-enriched uranium.

Nuclear power has a number of significant advantages in minimizing the impact of fossil fuels by contributing a larger share of electrical production.

And there are programs in place now to replace that high-enriched uranium fuel – even though it is in relatively small amounts in most reactors – with low-enriched uranium.

What is the impact on proliferation? As we already heard, the title of this meeting is "Nuclear Power without Nuclear Proliferation?" We could say that another interesting topic would be to reverse the title and say nuclear proliferation without nuclear power. It is important to remember that proliferation to date has not been predominantly the result of misuse of the civilian nuclear fuel cycle. It has been from dedicated, covert programs by some countries. This does not relieve us of the proliferation concerns that will come with the spread of nuclear power, but it is important to keep in mind.

It is important to remember that proliferation to date has not been predominantly the result of misuse of the civilian nuclear fuel cycle. It has been from dedicated, covert programs by some countries.

As I have already mentioned, you have to make weapons-usable materials. They do not exist in nature. With regard to proliferation, we must recognize that over the last 50 years or so a series of barriers has made us feel, legitimately or not, more comfortable with how difficult it would be for people to get their hands on nuclear weapons. I am going to read a small list of these barriers. What I want you to note is that every one of these items has essentially been eroded now.

First, we thought that there were relatively small quantities of special nuclear materials, or weapons-usable materials, and that they were in a very small number of locations. The United States had a small supply and kept it hidden. And the Russians and the Chinese had a small supply. That is no longer the case. Second, we thought that the design of a nuclear weapon was a closely held secret, and that it was difficult to make a weapon.

Countries who want access to nuclear power plants at market prices ought to be able to have it, if they have the capability and the infrastructure to take care of them, show that they can deal with them safely and securely, and meet international standards.

We had a degree of comfort that, even if a country or a sophisticated subnational group somehow got their hands on the material, they would not be able to make a weapon. We now expect that they have some chance of making a nuclear weapon. Third, we used to believe that terrorists did not have a motivation for using weapons of mass destruction. As Brian Jenkins of RAND Corporation used to say, "What terrorists want is not a lot of people dead. They want a lot of people looking." That was the pre-9/11 world. The post-9/11 world is different. We also used to believe that terrorists were unwilling to sacrifice themselves, so surely they are not going to detonate a nuclear weapon or develop one if there is any risk to them. This is no longer the case. We used to believe that terrorists cannot attract sophisticated people; they can convince only teenagers to strap something to their backs and blow themselves up. Clearly this is not the case. Very sophisticated and educated people are now part of subnational groups. And last, we used to believe that terrorist groups had to be very small and isolated or else they would get discovered. That was the intelligence mantra of 20 years ago, when we first had the rise of international terrorism. The single strongest remaining barrier is to prevent adversaries from acquiring the necessary weapons usable materials.

Thus, the importance of getting our hands around enrichment and reprocessing capabilities, which are the techniques necessary to get weapons-usable material. Getting that under control should be the central focus of the coming 20 years.

Finally, is there a window of opportunity and what needs to be done? We need to ask ourselves, are we going to be incremental or are we going to be guided by a vision? In 1953 President Eisenhower launched the Atoms for Peace initiative. A lot of what he said did not come to pass, but it began an international engagement. It started a dialogue, which led to a number of things, among them the Nonproliferation Treaty and the International Atomic Energy Agency (IAEA), which inspects countries to see if they are using their nuclear facilities and materials properly. Although there are limitations with IAEA inspections, all but a very few countries have signed on. The nuclear weapons states said that they would help the non-nuclear-weapons states get access to peaceful nuclear technology and that they would move toward ultimate disarmament. The non-nuclear-weapons states pledged not to move toward nuclear weapons. It has not worked perfectly, but in terms of proliferation, it has worked pretty well so far.

What might be some of the key components of a new arrangement for the coming decades? Countries who want access to nuclear power plants at market prices ought to be able to have it, if they have the capability and the infrastructure to take care of them, show that they can deal with them safely and securely, and meet international standards – like adhering fully to IAEA membership requirements, meeting IAEA safeguards, and signing up for additional protocols, which allow for additional inspections. Nuclear power plants themselves are not a major proliferation concern. The fuel that comes in is low-enriched uranium. True, when it comes out of being irradiated in the reactor, it contains some plutonium. But the spent fuel elements are highly self-protecting.

Second, countries will need assured fuel supplies. As I mentioned, these plants have to run for decades. U.S. nuclear power plants were licensed for 40 years. They are now being relicensed for 60 years, and current research is leaning toward 80 years. That is the stability it takes to get the kind of return on investment that is necessary.

Third, weapons-usable materials inventories should be driven down toward zero. In my view, the safest place for excess plutonium is

in the core of a nuclear power plant, where it is producing energy and becoming radio actively self-protecting. If we can find ways to keep it in there long enough so that what comes out is not weapons-usable, even if reprocessed, that would be a wonderful thing.

Fourth, we need to eliminate the rationale for countries to have national enrichment and reprocessing. We need to lead by example, and we need to do it in a regional and international framework. The only way this is going to work is if spent fuel is returned either to the country of origin or to a third country for eventual disposal in a repository. It is difficult to build repositories. We need to find a way to turn the argument around, from repositories being a garbage dump for our nation's nuclear waste to repositories being an integral part of a national security regime that builds national well-being and international stability.

So is it business as usual or do we need to do something? One can make an argument that we have a window of opportunity here. We need to be proactive. We need to partner with the developed world and start listening to the developing world. We need to give the developing world an opportunity to grow and improve their standard of living while at the same time improving U.S. and world security. We need to give them a stake in the future; otherwise it is going to look like the "haves" are continuing to try to keep the "have-nots" out of the business. I believe a new vision, a new partnership, a new bargain will not be easy or happen quickly. But success would leave the world a much better place.

Questions and Answers

Question: I have been listening with great interest. I am a historian, and not a political scientist or a physicist. How do we control the states that have joined the treaty for nonproliferation? I am thinking, of course, of Iran. It seems to me that, in dealing with that situation, which has been approved, presumably, by the International Atomic Energy Commission, we have refused to talk to Iran about proliferation and threatened them instead. This is creating strain between Iran and the rest of the world. Iran is very adamant. They are threatening, too.

There is a tension between the United States policy of regime change and our policy of nonproliferation.

We have, of course, ships there that are ready to take action against this threat. And we have Israel, which for its own reasons, and very good reasons, is going to make a surgical strike, which will affect atomic energy, and even atomic weapons perhaps, in Iran. And Israel has struck against a treaty nation, Syria, very recently. Neither side will admit it happened, but it's been treated as a strike by intelligence here in the United States. How have nations agreed to follow through on the arrangements for the Nonproliferation Treaty other than threatening each other?

Perry: Any way of dealing with Iran requires two broad approaches. First, we must isolate Iran, so that they are the deviant. The only way the United States can do that is to reduce its own emphasis on nuclear weapons. That was the theme of this op-ed that we published in *The Wall Street Journal* earlier this year. The United States has to be moving seriously toward nuclear weapons elimination. If we do that and get most of the rest of the world to join us, then the rationale that Iran uses for going forward is greatly diminished.

Second, if that is not enough, we have to be prepared for what I would call coercive diplomacy. In my judgment, the most effective coercion against Iran would be economic coercion. It will not work if we are the only ones trying to apply it. But if we can get a serious buy-in from the European countries, including Russia, then we have substantial leverage to use against Iran, without entailing military threats.

Arbatov: I would add that, since collective action is needed, the United States has to take into account the objections of other nations and international politics. The Iranian nuclear program was started under Shah with great help and prompting from the United States. The program that was planned under Shah was even bigger than the present program that Iran is planning, and included large-scale enrichment. Then the regime changed. Americans do not like the present regime. But other countries have a different attitude. They may dislike it, but not so much as to go to war or to sustain very painful economic sanctions, like an oil embargo. Many countries, including some American allies, are importing oil from Iran and depend on Iran. In Russia, Iran is a matter of concern, but not the primary concern. You would be surprised if you read present-day Russian official documents and political statements, in particular, the military literature. When they are listing the threats Russia is facing internationally, the number one threat would be American deployment of ballistic missile defenses, followed by American deployment of new nuclear weapons and new conventional weapons, such as precision-targeted weapons; and the extension of NATO to the east, toward Russian borders, toward post-Soviet space. And way down on the list would be Iran, proliferation, and terrorism. In order for Russia to cooperate genuinely with very painful and radical measures against Iran, the United States has to do something with respect to the issues that concern Russians. You cannot tell Russians: "Join us in a blockade or military action. As for the extension of NATO and ballistic missile defense, you are wrong in your concerns. We are not going to take it into account." This is not going to work.

Sagan: I would just add one very brief point. In an article called "How to Stop Tehran from Getting the Bomb," in *Foreign Affairs* last year, I laid out an argument saying that there is a tension between the United States policy of regime change and our policy of nonproliferation, because the political interest in Iran in getting a nuclear weapon is largely because they feel threatened by us. So while I agree with the notion that we may have to move toward even more coercive economic diplomacy, through the United Nations and through our European allies, we have to make our threats conditional upon their not agreeing on the nuclear program. But if they do agree, we have to reverse course in a credible manner and stop threatening to use force against them for regime-change purposes. It is a tough balancing act that we are going to face. Right now, we are seeing the worst of both worlds. We are not having effective coercion, and we are threatening them in ways that build up their interest.

The United States has to be moving seriously toward nuclear weapons elimination.

Perry: I would like to agree with what Scott just said but also build upon what Alexei said, which is the importance of getting Russian cooperation. In that first chart, which showed the number of nuclear nations, you saw a big bump and then a great drop. I was Secretary of Defense during the years that we had that drop. I know exactly what was entailed in making that happen: full and deep technical and diplomatic cooperation between the United States and Russia. Without that cooperation, none of that would have happened. Today, I cannot even imagine getting that kind of cooperation, even though it is in both Russia's and America's national interests. Today, the antagonism between the two countries is too great. But we must get that cooperation in order to have success in this area.

Question: My question is about credible fuel-supply guarantees. I was wondering if any or all of the panelists could elaborate on what some sort of multilateral system might look like. In one of the earlier rounds of negotiations with Iran, just as Russia was trying to convince Tehran that they would provide a consistent flow of fuel for the nuclear program, the flow of natural gas, I believe it was, to Europe suddenly stopped. My other question is whom would the United States entrust to provide a guaranteed supply of nuclear fuel to us, if we were forced to practice what we preach?

Isaacs: First, a number of initiatives – one by President Bush, one by Director General of the IAEA Mohamed El Baradei – are all looking at ways to provide an assurance of adequate fuel supply for decades, in return for countries forgoing national enrichment and/or reprocessing plants. How do you provide assurance to a country that is about to invest several billion dollars in a nuclear power plant that the world will provide them the fuel that they are going to need for the next 80, or even just 40, years for that plant? It is a tall assignment considering what these small countries want: a marketplace where they can go for their fuel. They do not want a cartel for this fuel, which is the way our assurances have sounded: We will take care of you. Trust us.

Right now there is a marketplace. In fact, there are more enrichment services right now than necessary. So the small countries have what they want. Enrichment prices have risen dramatically, but since fuel is a small part of the cost of a nuclear power plant – constructing it is the big part – the price of fuel has to get very high before it becomes a pain. So how are you going to provide assured fuel supplies? I do not have the answer. A lot of people are looking carefully at this issue right now. But part of the answer is to internationalize or regionalize or 'multiparty-ize' the nuclear fuel assurances: we have to move, in my view, beyond a small number of nuclear fuel suppliers to some kind of mechanism whereby both the developed countries and the developing countries have a stake in providing fuel assurance, if they meet a certain number of criteria – for example, showing that they have a track record of adhering to IAEA safeguards, a track record of transparency, etc. Over time, countries should be able to earn their way into having those sensitive parts of the fuel cycle. Right now, Japan is the only non-nuclear-weapons state that has the full fuel cycle. They are just now opening their Rokkasho plant, a $20 billion plant to reprocess their spent nuclear fuel. This is a huge investment on their part, made largely for energy security. You cannot say it is based on short-term economics. It is probably costing them a fortune. But they want to be able to dictate their own future.

So there is no short, easy solution. There is an adequate supply of uranium for the next 20 or more years, without going to reprocessing. Ultimately, if we see the kind of growth in nuclear power that we are likely to see, we will witness more impetus toward more reprocessing. And after 20 years, we will have to start addressing the issue of putting various kinds of technology in place and preventing people from misusing that technology and getting plutonium out of it. But for the foreseeable future there is enough uranium, enough enrichment services, out there. We ought to be moving, as I said, by example to provide countries in good standing with the opportunity to have a piece of that action.

Perry: On this question, the Nuclear Threat Initiative, which I mentioned earlier, believes that this is a key to being able to achieve the goals we are talking about, to have an international supply – a bank, you might say – that guarantees an assured supply at reasonable prices. They have convinced Warren Buffett to put forward $50 million to set up that bank. Operated by the International Atomic Energy Agency, it would offer guaranteed fuel at reasonable prices to all countries willing to forgo making their own fuel supply. This is far from operational at this stage, but that is the direction they are headed.

The Russian-Siberian town of Angarsk, Russia, together with Kazakhstan, is building a multilateral reprocessing plant, which is supposed to provide assured supplies of low-enriched uranium to countries that are not developing their own uranium enrichment technology.

Sagan: We have heard the example of Russia, which on the one hand is trying to convince Iran to buy enriched uranium from them, and at the same time cutting off other fuel supplies. Alexei, could you comment on the Russian perspective on guarantees of fuel supplies?

Arbatov: Russia is now in the process of implementing this idea. The Russian-Siberian town of Angarsk, Russia, together with Kazakhstan, is building a multilateral reprocessing plant, which is supposed to provide assured supplies of low-enriched uranium to countries that are not developing their own uranium enrichment technology. President Putin, today visiting Tehran, will continue his efforts to persuade Iran to join this project and to stop its own uranium enrichment program.

With respect to gas supplies, Russia behaved in a very rude manner toward transit coun-

tries, which are post-Soviet states. That is mostly because Gazprom – the state monopolist in Russia that handles all gas extraction, transportation, and supply – has its own predatory economic policy. I do not approve of that. And I do not approve of the way it was done, especially with respect to Ukraine, the transit country, and to Georgia, the buying country. But having said that, I want to make it absolutely clear that Russia did not place an embargo. It was simply trying to make Ukraine pay world prices for gas. Before, Ukraine was supplied with natural gas at much lower prices, in line with previous agreements and treaties. Eventually Russia decided, "Why should we provide all those countries – former Soviet republics – with discounted gas and oil prices, and make our taxpayers pay for their energy?"

So Russia did this to Ukraine, which the United States likes very much; and Belarus, which the United States dislikes; and Georgia, which the United States likes; and Armenia, which Russia likes very much. It was not political blackmail; it was just the economic policy of Gazprom, which said to the Russian government, "Let's stop those subsidies. Let's charge them world prices because we are not getting anything from them in return. Why should we play this new imperial game of providing economic benefits in return for political loyalty? Let's stop all that." I think that is a healthy policy. The only negative was the way in which the policy was carried out. But the fact that it was bad for all those countries is a sign that it was not politically motivated. It was economically motivated, and economic policy is quite rude and predatory.

Now, with respect to international enrichment cycles, I would like to say only one thing. The idea is wonderful. But as always happens, the devil is in the details. The logic is that we will build international enrichment plants and provide an assured supply of low-enriched uranium to countries that do not build their own enrichment capabilities. Now, if we were to provide them with this low-enriched uranium at average world prices, what is the incentive for them to buy it? They could buy it on the free market or they could build their own enrichment facility. If they invest in their own facility, they could eventually get low-enriched uranium at a much lower price. So we have to provide them with an economic incentive. We have to provide them with fuel, or low-enriched uranium, at much lower prices. But how do we define who is eligible to receive that? The moment we start this operation, all countries that have at least one – even one – research reactor will say, "We want to get a low-cost assured supply. Otherwise, we will go for our own enrichment capability." And you will not be able to deny them that. So basically, you are talking about an internationally established assurance of supply to all countries of the world, provided they do not develop their own enrichment capability. And that effectively cancels the international market in this particular area. We could retain markets in other nuclear areas. But in that supply of fuel, or low-enriched uranium, we are doing away with the market. We are starting a long program of state-regulated or internationally regulated prices to all countries of the world that have at least one reactor.

I believe the lynchpin potential here is not just to provide them fresh fuel assurance but to link it with spent fuel take back, so that we provide these countries with a full ability to take advantage of nuclear power.

Isaacs: I agree with what Alexei said about this issue. You have to provide the developing world with something that they need. If you asked the developing world how this scheme looks, those countries would say that it looks like the developed world, and the United States in particular, is trying to establish a cartel rather than trying to give the developing world a hand. What they need much more is help with the backend of the fuel cycle, dealing with the spent nuclear fuel.

Here is the win-win possibility. Right now 85 percent of the nuclear power in the world is in the developed world. Only a small fraction at the moment is in the developing world. Those countries are all going to have to develop their own repositories. I do not believe it is going to happen. Those facilities are incredibly expensive. They are very difficult to site, and they take decades to build. As I mentioned, that is the reason 15 of the 30 countries right now have fewer than five reactors. They are going to have to go through the same agony we are going through for Yucca Mountain for very small amounts of fuel. So I believe the lynchpin potential here is not just to provide them fresh fuel assurance but to link it with spent fuel take back, so that we provide these countries with a full ability to take advantage of nuclear power. They will not have to deal with that nuclear waste. We will.

This is a huge leap for us. We cannot even handle our own waste right now, let alone the political problem. But the only reason to do it is because it makes sense. It is not going to happen in two or five years, but we have to find a way. First, we are taking away spent fuel with plutonium in it. So it is in our security interest. Second, we are going to have to deal with a small amount of the spent fuel. All the major nuclear-developed countries, and Australia and Canada, who supply all the uranium, have some obligation for what happens to that material after it has been processed. So this is a potential win-win situation if we frame this problem appropriately.

Arbatov: I agree that that is a great incentive. Unfortunately, it is a great incentive for all countries except those who want to develop nuclear weapons. Because those who want nuclear weapons will want to keep the irradiated fuel to extract plutonium. And you are designing this program in order to prevent proliferation. This is a Catch-22.

Isaacs: I do not see it as a Catch-22. In fact, it will help us separate out the countries that are planning to build nuclear weapons.

Sagan: You have seen some of the major debates that will be occurring and the need for social scientists and physical scientists and engineers to work together, because of the complicated nature of these problems. The problems in this area are not divided by the disciplines with which we divide our universities. I would like to thank our panelists for addressing these issues today. ■

Academy Meetings

Lucius Barker (Stanford University) and John Brauman (Stanford University)

Leslie Berlowitz (American Academy), Jesse Choper (University of California, Berkeley), and Stephen D. Bechtel, Jr. (Bechtel Group, Inc.)

Harry Rowen (Stanford University) and Carl Kaysen (MIT)

Sidney Drell (Stanford University) and James Gaither (Sutter Hill Ventures)

Andreas Acrivos (City College of CUNY) and Stephen Ernst Harris (Stanford University)

The World's Energy Problem and What We Can Do About It

Steven Chu
Introduction by Robert J. Birgeneau

This presentation was given at the 1920th Stated Meeting, held at the University of California, Berkeley, on November 20, 2007.

Meltwater stream flowing into a large moulin of the Greenland ice sheet. Photo courtesy of Roger J. Braithwaite, University of Manchester, UK.

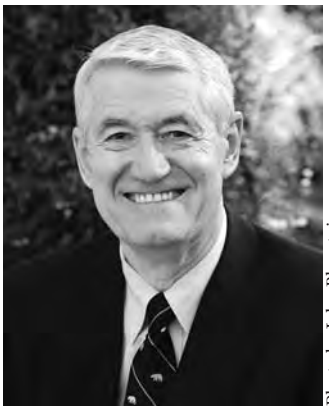


Photo by John Blaustein

Robert J. Birgeneau

Robert J. Birgeneau is Chancellor of the University of California, Berkeley. He has been a Fellow of the American Academy of Arts and Sciences since 1987.

Introduction

I am happy to welcome the American Academy back to the Berkeley campus and to greet so many of my fellow Academy members. The meetings that the Academy arranges on campus each year perform the valuable service of bringing together faculty from a wide range of disciplines who might otherwise not meet. I am proud to say that this university, with its broad array of excellent faculty in so many fields, is taking a role in multidisciplinary research leading toward practical solutions to some of the world's great challenges. All of us know that there will always be intellectual challenges that can only be solved by one brilliant mind. However, many of today's challenges can only be addressed with a multidisciplinary approach.

At Berkeley we recently initiated several new and exciting multidisciplinary initiatives. One seeks practical solutions to global poverty. Another initiative studies the challenges of multicultural societies. A third is searching for ways to mitigate life-threatening diseases through stem-cell research. A fourth is looking for alternative clean-energy solutions to reduce our energy demands.

This last multidisciplinary initiative is the largest of our new initiatives. With the success of the BP grant for the development of biofuels for transportation, which was formally signed this past week, and our many other approaches to alternative energy (from inventing solar energy devices to exploring energy conservation methods and studying the social impact of new technologies), Berkeley is strongly positioned to be a global leader in energy research.

Few people on this campus are better qualified to tell us about alternative energy research than our speaker this evening, Steven Chu. Steve is a graduate of Berkeley with a

Ph.D. in physics; in fact, his thesis advisor is here. He was also a postdoc at Berkeley. After many years, he has returned as Professor of Physics and of Molecular and Cell Biology and as Director of the Lawrence Berkeley National Laboratory. Steve happens to be an old friend of mine who arrived at Bell Labs not long after I left to go to MIT. At Bell, he invented optical tweezers, a laser trap that earned him the Nobel Prize in 1997. Although his Nobel Prize discoveries were in physics, they had applications not only in physics but also in both microbiology and nanoscience.

At Stanford, as the Theodore and Frances Geballe Professor of Physics and Applied Physics, Steve helped start Bio-X, a multidisciplinary initiative linking the physical and biological sciences with engineering and medicine. Steve has long been interested in the conversion of solar energy into a large-scale alternative to fossil fuels. He came back to Berkeley with an incredible passion for meaningful research on climate change and energy self-sufficiency, and played a central role in creating a new Energy Biosciences Institute for multidisciplinary research and institutional collaboration on biofuels, which will help take us from the laboratory to the fuel pump.

Most recently, Steve completed work on a major international report on energy sustainability to the InterAcademy Council. His civic contributions are numerous. A member of the Augustine committee that produced in 2006 the now-famous report, *Rising Above the Gathering Storm,* he has served on advisory committees to the Director of the National Institutes of Health and the National Nuclear Security Agency, and on the Executive Committee of the National Academy of Sciences's Board of Physics and Astronomy. Steve is also on the boards of foundations, universities, and corporations, including the Hewlett Foundation, the University of Rochester, and NVIDIA, and on the scientific boards of the Moore Foundation, Helicos, and Nabsys.

A Fellow of the American Academy, Steve is an active participant in its initiative on alternative models for the federal funding of science and on the potential to nurture the next generation of scientists. It is with great pleasure that I call my friend and colleague Steven Chu to the podium.

Steven Chu

Steven Chu is Director of the Lawrence Berkeley National Laboratory and Professor of Physics and Professor of Molecular and Cell Biology at the University of California, Berkeley. He has been a Fellow of the American Academy of Arts and Sciences since 1992.

I am delighted to be here to talk about something I care about deeply: our energy problem. Rather than focusing on just biofuels, though, I want to take a step back and look at the broader problem and options.

First, with our prodigious use of energy, we have created a number of serious environmental concerns, particularly climate change. The problem starts locally, but eventually affects everyone globally. I began to appreciate the extent of the problem when I worked on a study for the InterAcademy Council, a small group of people who represent over 150 academies of science, medicine, and engineering around the world. Second, about one-third

With our prodigious use of energy, we have created a number of serious environmental concerns, particularly climate change.

of the people in the world have only primitive forms of energy: twigs, dung, lumps of coal. Some 1.6 billion people do not have electricity. This many people lacking access to modern forms of energy is an enormous issue. Third, competition is growing for increasingly rare energy resources, particularly oil and gas. Countries have gone to war for far less than this.

Today I am going to focus on the first aspect of our energy problem: the environmental complications created by our use of energy. In Figure 1, we see how much the Earth has warmed up from 1860 to 2000 – keep in mind that 140 years is nothing on a geological timeline. Figure 2 illustrates the temperature today and looks back 420,000 years. Over that time, we have gone through an ice age, a rapid warming period, another ice age, and another rapid warming period. The temperatures depicted here were measured in oxygen samples taken from the ice sheets in Antarctica. Also plotted are concentrations of carbon dioxide and methane over time.

Looking at these figures, you might ask, "Well, what is the problem? We are in a warm period, but over the next 100,000

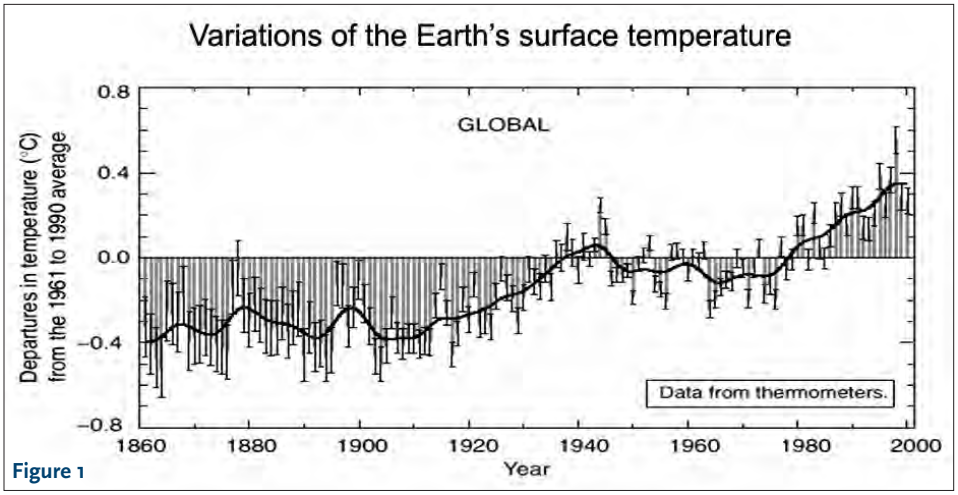


Figure 1

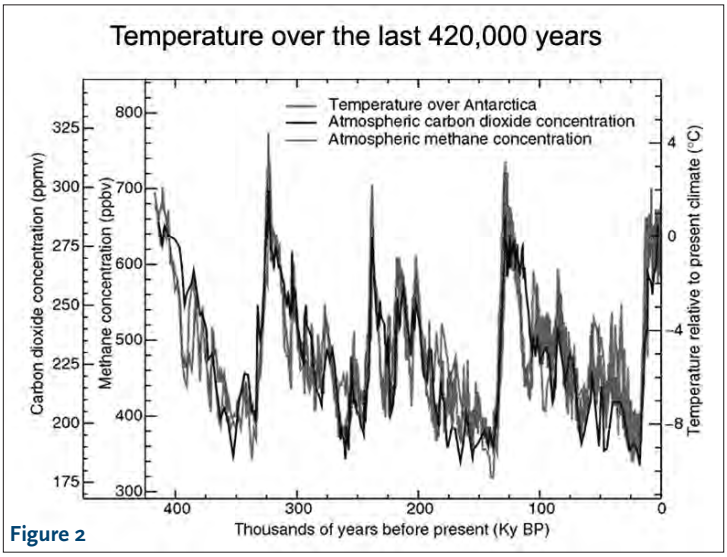


Figure 2

years, shouldn't we be more concerned about another ice age?" The reason scientists are concerned about global warming is because the current CO_2 level is at 380 parts per million (ppm), which is off the scale in Figure 2. In terms of total greenhouse gases (CO_2, methane, nitrogen oxide, etc.) we have an effect CO_2 concentration of 420 ppm. Moreover, most of this change occurred in roughly a hundred years, 1,000 times shorter than the time it took for the Earth to cool down from its warm periods.

What caused these shifts in the past? We now know that astronomical changes in the eccentricity of the Earth's orbit, a slight tip in the Earth, caused the initial rise. But that slight change in eccentricity does not account for the entire shift. One possibility is that positive feedback effects played a role; as the Earth warmed up, greenhouse gases trapped in the oceans and on land were released. The release of the greenhouse gases continued the warming process. The conjecture is that plants and other organisms that fix CO_2 prosper in a warmer climate that has more CO_2, and these organisms slowly sequester the carbon dioxide, causing a slow cooling.

If we followed a business as usual scenario, the Stern Review Report states that we have a greater than 50 percent probability of exceeding a 5°C global average temperature change. What will happen if this occurs? The good news is that life on Earth will go on. The bad news is that it will be a very different place. Twenty-five thousand years ago, the world was roughly 6 to 8°C colder. During this time, all of Canada and the United States down to Ohio and Pennsylvania were covered in a sheet of ice year round. A few degrees change in the *average* temperature has a profound effect on the Earth. Moreover, if this change occurs in less than a century, many species will face extinction. Life on Earth will almost certainly continue, since we know that 50 million years ago, the Earth had much higher levels of CO_2 and was more than 10°C warmer. In a much warmer world, however, it will not be as inviting a place for polar bears or people.

What is the evidence that humans are causing this warming? Figure 3 shows the concentration of greenhouse gases – carbon dioxide, methane, nitrous oxide – over the last thousand years. The lines are fairly flat until about 1750, when levels suddenly start to increase. It is at about that time that countries began to industrialize, and we began to burn coal in larger amounts.

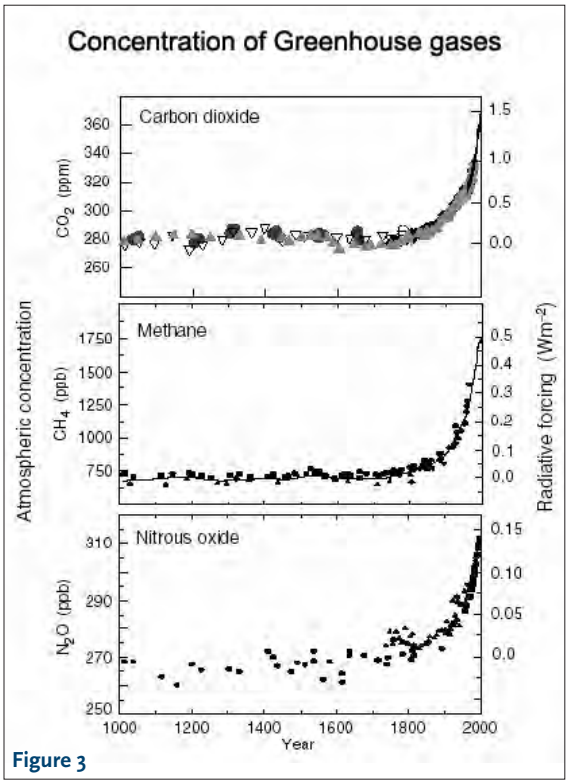


Figure 3

There is a growing preponderance of evidence that suggests that human activity was the major factor in the observed change in the average temperature of the Earth.

Yogi Berra, the great American philosopher of the twentieth century, was reputed to have said, "Predictions are hard to make, especially about the future." In order to get better about making predictions of the future, one can practice by trying to predict the past. I am going to take you through a prediction of what may have happened in the past. The dark line in Figure 4 is the observed average temperature increase over the world. The gray line represents a climate model of what the temperature change should have been due to natural causes, such as solar variations, volcanic activity, and so on. In the second graph, the gray line is a computer model that also includes the increase of greenhouse gases as shown in Figure 3. As we see, the climate model was able to predict the past, which gives us more confidence that it may be able to predict the future.

The bottom graph in Figure 4 suggests that humans might have caused climate change. Does it prove humans caused it? No. However, there is a growing preponderance of evidence that suggests that human activity was the major factor in the observed change in the average temperature of the Earth. This is why the Intergovernmental Panel on Climate Change Report in 1990 was not willing to say that any climate change we measure is due to humans, whereas in 2006 it was saying that there is a greater than 90 percent chance it was caused predominantly by humans.

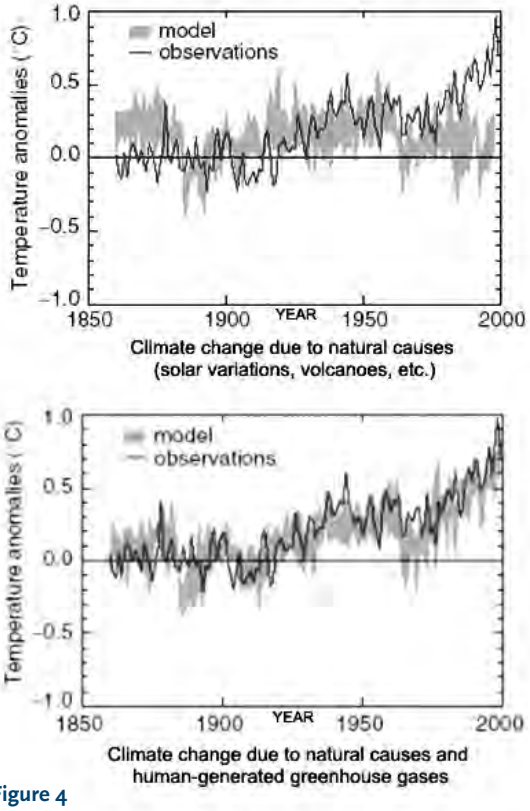


Figure 4

So again, with the caveat of Yogi Berra's wisdom about making predictions, let me discuss some predicted effects of climate change. People are forecasting many events, including a dramatic increase in species extinction, a rise in sea level, increased damage from floods, storms, and wildfires, and so on. There is mounting evidence that many of these predictions are beginning to happen, and in many cases, faster than what was predicted in the 1980s.

I believe that it is possible to continue to consume large amounts of energy that have led to our prosperity while dramatically decreasing the production of CO_2.

Figure 5

In Figure 5, we see images of the snow pack around the North Pole region, reconstructed from microwave radiometric and microwave imaging satellites. These images were made from data taken in September, when the Arctic melting is at a maximum. When the snow and ice melt to expose a darker ocean, there is a positive feedback mechanism that occurs. As more snow and ice melt, the area of the heat-absorbing dark ocean increases, allowing the Earth to absorb more heat, which leads to more melting of the reflective ice and snow.

As the ice pack melts, will it cause a rise in sea level? No, because this ice is in water, and because of our understanding of buoyancy: the combined combination of water and ice floating on top will not change sea level height when the ice melts. It is the decrease of snow and ice on land that will cause a rise in sea level.

The images in Figure 6 show the area of the Greenland ice sheet in 1992 and then in 2002 (the record

It is vitally important that the developing countries learn to leapfrog past the mistakes of the developed world and grow into prosperity in a more environmentally friendly way.

melt of 2002 was exceeded in 2005). The bulk of the ice sheet in central Greenland is 2 to 3 kilometers thick, and the volume of ice, if it completely melts, will cause the sea level to rise by 7 meters. Here again there will be positive feedback effects. As the sheet melts to lower altitudes, the surface of the ice will be exposed to warmer conditions. Once the darker ground is exposed, more sunlight is absorbed.

The melting is occurring faster than we predicted ten years ago due to two reasons. The snow is darker than we thought because there is more soot than originally estimated. We also did not fully appreciate the fact that in the summer months, when the ice melts, vertical shafts (moulins) permit water to flow to the base of the ice sheet. The water lubricates the interface between the ice pack and land, allowing the ice sheet to flow into the sea faster. Over the past decade, Jacobshaven, an extremely fast-moving glacier on the western side of Greenland, has doubled its rate of flow into the ocean, and is now moving at a speed of 40 meters per day. Global warming is giving a new meaning to the phrase "glacial speed."

Now let us shift our focus to energy consumption. The United States is the leader in both wealth and energy consumption per capita, but our energy consumption per unit of wealth (measured as the GDP per capita) is leveling off. There are several reasons: increased energy efficiency, and a shift from a heavy industry-based economy to a service-based economy.

The more relevant issue is not energy consumption *per se*, but the amount of greenhouse gases one emits while using the energy. I believe that it is possible to continue to consume large amounts of energy that have led

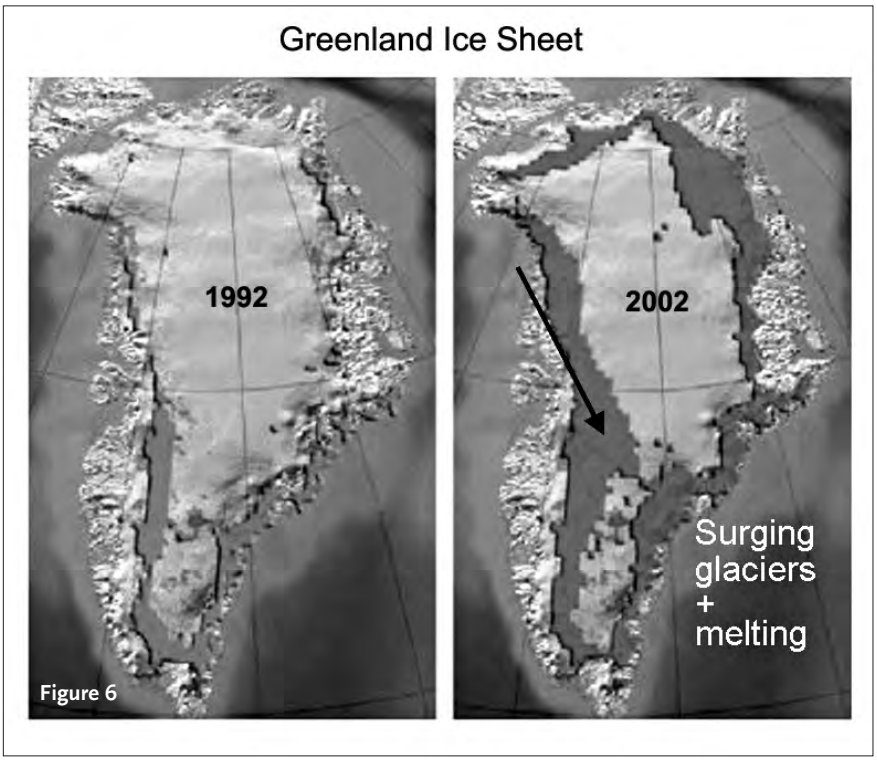


Figure 6

to prosperity while dramatically decreasing the production of CO_2. The governor of California, Arnold Schwarzenegger, has set a target of reducing the state's carbon emissions by a factor of five by mid-century. Others think that dropping by a factor of ten may be needed to stabilize the carbon in the atmosphere and allow the rest of the world's population, which will peak at approximately 9 to 10 billion people, to enjoy the same standard of living as the United States.

Are China and India going to follow in our footsteps in economic development and CO_2 emissions? Historically, as developing countries increased their wealth, they began to realize that their industrial development also generated considerable pollution of the air and water. The developed world made some terrible mistakes, and many people paid a heavy price for the initially unrestrained emission of many forms of pollutants. When the world was less populated (such as at the beginning of the industrial revolution), the consequences of the pollution were mostly localized to a particular region. In a world of 6.5 billion people, the emissions from burning coal (SO_2, nitrogen oxides, particulate matter, mercury, as well as CO_2) are becoming a worldwide problem. If China and India develop as the United States has, we will face an enormous challenge, and it is vitally important that the developing countries learn to leapfrog past the mistakes of the developed world and grow into prosperity in a more environmentally friendly way.

We need to maximize energy efficiency and decrease energy use.

The developed countries, and especially the United States, must dramatically reduce their carbon emissions. A dual strategy is needed: 1) We need to maximize energy efficiency and decrease energy use. Increasing the efficient use of energy will remain the lowest hanging fruit among the set of solutions for the next several decades. 2) We have to develop new sources of clean, carbon-neutral sources of energy.

Will the free market take care of the energy/climate change problem? The answer is resoundingly no. Free markets fail when there is a "commons problem": a problem that involves a shared resource. The term originated with the idea in medieval Europe of the common area of a town, where the local folk could graze their livestock, gather wood, etc. The town commons was a shared resource. Pollution is a "commons" problem. For example, if you are a city that is located on or near a river that is shared by many cities, it is much cheaper to dump raw sewage into the river than to treat it, especially if there are no cities upstream from you. However, to the cities downstream from the polluter, it is much more expensive to clean up the water than to suffer the health, economic, and social consequences of a polluted river. As a shared resource, the wisest and most economical use of the river is for all cities to treat their sewage. International fishing is also a commons problem that transcends national, and even continental, borders. If a fisherman (or nation) does not have total control over the asset, some people will want their fair share of the fish, and some maybe a bit more than their "share." Unfortunately, the result is that an estimated 24 percent of the world's fisheries have been either overexploited or depleted (FAO estimate). Climate change is the biggest commons problem we are facing today, and free markets will never respond to this problem. Ultimately, international agreements between governments have to intervene with a combination of regulations and fiscal incentives.

California has done a remarkable job since the mid-1970s of flattening electricity consumption per person, while the rest of the United States experienced a 60 percent increase. An important part of this energy savings was a provision that California wrote into its regulation of utility companies, separating the profits of a utility company from its sale of energy. They realized that it is not the total profit but the return on investment that investors really care about. If energy companies could make that return reasonable and stable, energy would still be a good investment. Furthermore, for any energy conservation measure that a utility company adopted, they could automatically pass that cost onto the ratepayer. Only three other states in the Union have adopted these measures, but we are trying to get the word out to the rest of the country and even to the rest of the world.

In my opinion, the biggest energy savings will occur in buildings. The United States spends nearly 40 percent of its energy in commercial and residential buildings. From talking to knowledgeable architects and design engineers, I learned that investments in energy

We have to develop new sources of clean, carbon-neutral sources of energy.

efficiency in a new building that have a payback time of less than five or six years in many instances can reduce energy consumption by more than a factor of two. When a university plans to add a new building to its campus, and hopefully a building that will be useful for at least 50 years, most universities until very recently have been unwilling to invest the additional 5 percent to make the building more energy efficient. The reason these "better-than-free" energy investments are not currently being made is because the source of money that operates and maintains a building is not the same as the source that builds and/or purchases the building. With slight adjustments, I believe the ability to make better macroeconomic decisions will go a long way to improving the use of energy.

The Berkeley Lab helped design the new San Francisco Federal Building. It uses natural chimney-like ventilation instead of mechanical cooling or ventilation in the open-plan perimeter office space. The exposed structural concrete allows for thermal inertia to take advantage of the cool nights in San Francisco. It also incorporates as much natural lighting as possible. As a result of the success of the San Francisco Federal Building, the Lab has been asked to green the U.S. Capitol Building in Washington. Enthusiasm is growing for creating strong ties on campus with the School of Design, the School of Engineering, and the Lawrence Berkeley National Laboratory to work on projects such as these.

Let me turn now to potential supply-side solutions to the energy problem. Unfortunately, I do not think the world will turn its back on coal. It is too plentiful. Two-thirds of the world's known coal reserves are in the United States, Russia, China, and India, in that order. I am fairly certain that China and India will not turn their backs on coal. Nor will Russia because it wants to keep its coal for the domestic production of electricity and to sell its enormous oil and gas supplies on the international market for hard currency. China is building a coal-fired power plant every other week. As for the United States, the verdict is not yet in as to what we are doing, but there are now over 100 applications to the regulatory authorities to build coal plants. Coal plants are big investments; they cost anywhere from $300 million to $1 billion and have a 50-year lifetime. Once you make this kind of investment in a coal plant, there will be a huge incentive to use it for the life of the plant.

Coal plants vary widely in efficiency. Japan has the most efficient coal plants, at about 42 percent efficiency. Remarkably, U.S. plants are about 34 percent efficient. India's are 25 to 30 percent efficient. Going from 25 to 30 percent to 42 percent efficient is huge in terms of the amount of electricity per carbon unit. It is possible to increase the efficiency of electricity generation to better than 50 percent by using so-called "super critical" steam generation at higher temperatures. But in order to get to these much higher temperatures, we need more temperature-resistant, cost-effective metals or metal/ceramic composite materials. Thus, novel materials could decrease the amount of carbon emissions per unit of electricity generated by as much as 40 percent.

Biofuel production must be accomplished in an economically competitive and environmentally friendly way.

Electricity generation with natural gas or gasified coal has an even higher efficiency – roughly 60 percent – with today's technology. Why? Coal is dirty; burning it produces a lot of sulfur dioxide, nitrogen oxides, particulate matter, mercury, and radioactive uranium and thorium in the fly ash. These combustion products are also very corrosive. You cannot directly use the combustion gases in a conventional, pulverized coal plant to spin a turbine, but you can with natural gas or the syn-gas (a mixture of carbon monoxide and hydrogen) that results from gasifying coal. The exhaust of the turbine is so hot that you can put it in another heat exchanger and spin another turbine in a method called combined-cycle generation. Virtually all gas plants in the United States being built today are now combined-cycle plants. The burning of coal releases roughly twice as much carbon dioxide per unit of energy produced when compared to natural gas.

Increasing the geothermal generation of energy should also be considered. Geothermal energy is actually a very clean form of fission energy, since the heat deep inside the Earth is generated by naturally occurring radioactive decay. A good geothermal energy source has a combination of hot, porous rock and a supply of replenishable water. Anywhere around the world, if one goes down into the earth, you automatically get heat. Water is needed to extract the heat in surrounding rock and transport this energy to the surface where it can be used. We have a few geothermal sources in California, and geothermal energy is a major component of Iceland's energy supply. The trouble is that the combination of porous rock and water is not found everywhere. However, new methods of introducing lateral fractures in rock and pumping water into this rock can greatly enhance the potential of geothermal sources. A recent MIT study estimates that with existing technology, enhanced geothermal energy can supply up to 10 percent of the base-load electricity generation in the United States. At Lawrence Berkeley National Laboratory, we are also exploring the possibility of using carbon dioxide as a heat transfer fluid.

Wind is also a very good source of renewable energy. In terms of cost, it is within 20 percent of being competitive with fossil fuel. Currently, the biggest windmills have a generating capacity of 3 million watts per windmill, with the wingspan of a 747 airplane. Even larger, 5 MW windmills are on the drawing board, with wingspans of 126 meters. The bigger the windmills get, the more efficient they become, and because they stand higher off the ground, they can intercept more wind energy. I asked a senior engineer at GE how big he thought they could get. He answered, "5 MW is about as big as they can get. Any bigger, and we can't ship the blades. They cannot make turns on conventional railroad tracks and highways."

Where are the best wind sites in the United States? The good news is that many sites are where there aren't many people. But that is also the bad news, because now we must transmit this energy over larger distances.

Many of the best sites are in the upper Midwestern states, such as North and South Dakota, and in the mountainous regions of the United States.

For any variable supply of energy, such as wind or solar PV, or any capital-intensive form of carbon-neutral energy, such as nuclear, a long-distance transmission system that connects these sources to multiple local grids makes them much more valuable. We do not have a truly national, long-distance electricity transmission system in the United States. Our current interlocking grid is comprised of a collection of local transmission systems that connect to each other.

We already know that high-voltage DC transmission is less expensive and more efficient than AC transmission for distances greater than roughly 500 kilometers. It costs less money for many reasons. With DC, you need only two conductors instead of three or four. Also, the right-of-way costs can be considerably less. If you have ever wondered why high-voltage transmission lines are so high in the air, it is not because of the danger of electrocuting somebody; it is because as the voltage changes back and forth, the electric field polarizes the earth with alternating electric fields. This coupling causes charges to move in the medium and dissipates energy. To decrease the energy loss, the lines are moved higher in the air. For that same reason, you can't put in a high-power AC transmission line underwater because this so-called "capacitive coupling" would be enormous. With DC transmission lines, there is no energy loss due to capacitive coupling, and underground or undersea high voltage lines are possible. Already, there is an underwater HVDC line that goes between Sweden and Germany, and more undersea lines are being planned in Europe and the United States.

We can also convert the sun's energy into transportation fuel. This conversion is possible by using plants, algae, or some other microbe. It is also possible to convert solar energy to electricity, and then use the electricity to drive chemical reactions to store the energy in the form of chemical fuel that can either be converted back into electricity or used as transportation fuel.

If we consider using plants, we have to ask if we can grow enough food to feed a growing world population as well as grow energy. Unfortunately, much of the world is desert, and thus not well-suited for growing plants. Southern California is mostly desert, and it is the use of energy that allowed us to move massive amounts of water needed for agriculture, and to supply major cities such as Los Angeles and San Diego. Since much of the world is desert (and since arable land is much more valuable than desert land), the harnessing of solar energy without the use of water will likely supply a greater fraction of our energy needs compared to biofuels. At the present time, solar thermal and photovoltaic electricity generation needs substantial subsidies to compete with fossil fuel generation of electricity. If we reduce the cost by roughly a factor of three, many more people would install solar generators on the tops of warehouses and their homes without subsidy. If we reduce the cost by a factor of ten, power companies would begin to install large generating stations in desert areas. At LBNL, we are exploring the use of nanotechnology to create a new generation of very inexpensive solar cells that can be massively deployed on rooftops and deserts.

In the end, we need to seek transportation energy solutions that are not based on nature.

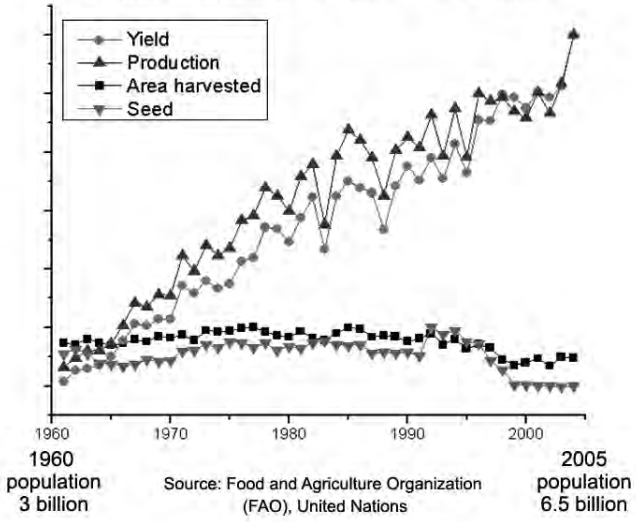


Figure 7

We are also looking at methods to greatly improve the conversion of sunlight to transportation fuel via biomass. Can we grow enough to feed the rising population of the world and still make transportation fuel? One of the greatest achievements of the twentieth century, at least as important as the invention of the transistor, the Internet, or the airplane, is the development of modern agriculture. Modern agriculture is heavily dependent on energy that goes beyond pumping water from wells or moving surface water in aqueduct systems. Our ability to make fertilizer from ammonia, which is synthesized from natural gas, transformed agriculture. At the beginning of the twentieth century, there was a huge problem with soil depletion, and Europe was contemplating importing soil or growing food abroad to feed its citizens. The ability to synthesize ammonia was considered so important that two *different* Nobel Prizes in chemistry were awarded for this work.

Even with the invention of fertilizer and irrigation, many scholars in the 1960s questioned whether we would ever be able to feed all the people in the world. The third vital advance in agriculture was the "Green Revolution": the creation of much higher yielding crops. Norman Borlaug, who was awarded the Nobel Peace Prize for breeding a dwarf wheat plant that produced 6 times as much wheat per acre as previous strains of wheat, prevented the imminent starvation of hundreds of millions of people. As a result of the Green Revolution, fertilizer, and irrigation, the amount of land devoted to the cultivation of grain actually decreased slightly while the production of grains increased fivefold, as shown in Figure 7. During this time, we went from a population of 3 billion in 1960 to 6.5 billion today, and fewer people are starving to death.

Returning to the growing of plants for biofuels, can we grow

plants that are better than corn? The answer is definitely "yes." As an example, consider the grass *Miscanthus*. This plant is perennial, and hence no tillage is needed for 10 years or more. As a perennial, it can be harvested annually, and like a weed whose roots are left in the ground, *Miscanthus* will grow back with a vengeance the following year. This plant is expected to produce ten times the amount of ethanol per acre as compared to corn, and without the heavy energy and water inputs that corn demands. As Bob mentioned, a half-billion-dollar grant was awarded to the University of California, Berkeley, with its partners the Berkeley Lab and the University of Illinois, to develop this pathway to alternative fuels.

What do we want to do with this investment? We want to develop better plants and develop better methods of breaking down the woody ligno-cellulose material into material that can be converted into a biofuel. In the BP-funded project, we also want to look at the socioeconomic and environmental impacts of biofuels. The deployment of any new technology often is accompanied by unintended consequences, and it is important to try to anticipate and minimize (and ideally to avoid) harmful consequences. Biofuel production must be accomplished in an economically competitive and environmentally friendly way.

We are beginning to explore how to break down cellulose and convert it into biofuels with a new technology called synthetic biology. Jay Keasling, a professor of chemical engineering at Berkeley and also the Director of the Physical Biosciences Division at Lawrence Berkeley Lab, has incorporated at least a dozen genes into the genome of *E.coli* to make a precursor to a new anti-malarial drug, artemisinin. His research grabbed the attention of the Gates Foundation and his discoveries are being commercialized by a startup company. This anti-malarial drug is on schedule for worldwide delivery to begin in 2008 – 2009. It turns out that this drug is a very close relative of a biofuel. In order for the startup company, Amyris, to get support from the Gates Foundation, it had to provide the anti-malarial drug at no profit. The financial incentive for the company is that the technical knowledge gained in the creation of this drug can be applied to make money in other applications. Very recently, Amyris is applying its synthetic biology technology to produce a biofuel that would be superior to ethanol.

Figure 8: Earth Rise from Apollo 8 (December 24, 1968)

In the end, we need to seek transportation energy solutions that are not based on nature. Because of the limits on production of fuel using arable land, we need to develop an artificial photosynthetic system that will split water into oxygen and hydrogen, and to extract carbon dioxide out of the atmosphere and reduce it to carbon monoxide. These are the first three ingredients that are needed to construct hydrocarbon fuel.

To advance energy research further and faster, we also should change the way we do research. Most university research starts with a proposal. It takes at least a year for the peer-review process to approve of the research. Then, you get three years to produce enough results to obtain additional funding.

We would like to fund research a little bit differently. At Bell Labs, where I worked for nine years, funding decisions were made much more quickly by technically superb managers. Individual genius was nurtured, but people were encouraged to form teams quickly in order to exploit ideas rapidly. The scientific direction was guided by collective wisdom and "managed" by top scientists with intimate, expert knowledge. Part of the responsibility of the Bell Labs managers was to encourage bold approaches. Some failure was expected, but there was an emphasis on recognizing failure quickly, and moving on to other opportunities. Communication between groups was a high priority, and technical memos were flying all over the place. Part of our goal is to create in the various LBNL/UC Berkeley energy institutes that we are establishing the same kind of stimulating intellectual cauldron that the veterans of Bell Labs experienced.

At his Nobel banquet in 1950, William Faulkner said, "I believe that man will not merely endure: he will prevail. He is immortal, not because he alone among creatures has an inexhaustible voice, but because he has a soul, a spirit, capable of compassion and sacrifice and endurance." With these virtues, we can and will prevail over this great energy challenge.

Let me close by reminding you of the image, shown in Figure 8, of "Earth Rise" taken by the astronauts of Apollo 8. This picture shows the dramatic contrast between a beautiful planet and the stark landscape of the moon. We know that there is nothing else within our reach. The energy problem is about preserving our planet. ■

D. B. Silin (Lawrence Berkeley National Laboratory) and Grigory Barenblatt (University of California, Berkeley)

Marvin Cohen (University of California, Berkeley) and Eugene Commins (University of California, Berkeley)

Jan de Vries (University of California, Berkeley) and Randy Schekman (University of California, Berkeley)

Karl Pister (University of California, Berkeley) and Christopher Edley (University of California, Berkeley)

Marvalee Wake (University of California, Berkeley), David Wake (University of California, Berkeley), Thomas Wake (Bow, WA), Jeremy Thorner (University of California, Berkeley), and Alexander Glazer (University of California, Berkeley)

New Members: Class of 2007

Class I: Mathematical and Physical Sciences

Section 1: Mathematics

F. Michael Christ

University of California, Berkeley, Berkeley, CA

Professor of Mathematics. Conducted analysis of global regularity (and its failure) for solutions of d-bar problems on pseudoconvex domains. Provided proof of ill-posedness of low regularity nonlinear Schrodinger equations (with Colliander and Tao). Characterized absolutely continuous spectrum and generalized eigenfunctions for second-order ODE with potentials on real line (with Kiselev).

Robert L. Griess, Jr.

University of Michigan, Ann Arbor, MI

Professor of Mathematics. Accomplished construction of the "Monster" sporadic finite simple group, not only for the first time, but also entirely by hand without the aid of a computer. Connections have emerged with areas as diverse as string theory in physics to very sophisticated number theory in mathematics itself.

Ehud Hrushovski

Hebrew University of Jerusalem, Jerusalem, Israel

Professor of Mathematics. Applied methods and theorems from model theory to other parts of mathematics, particularly arithmetic algebraic geometry, including the Mordell-Lang conjecture for function fields and a case of the Jacobi conjecture for difference fields. Advanced model theory, making algebra appear inherently rather than being imposed.

Victor Kac

Massachusetts Institute of Technology, Cambridge, MA

Professor of Mathematics. Founder of representation theory of infinite-dimensional Lie (super) algebras. Codiscoverer of Kac-Moody algebras. Creator of the theory of finite-dimensional and linearly compact Lie superalgebras. Other discoveries include Weyl-Kac character formula, Kac determinant formula, and vertex operator construction, crucial for integrable systems, conformal field theory, and string theory. Awarded the Wigner Medal in recognition of work on affine Lie algebras.

Peter Wai-Kwong Li

University of California, Irvine, Irvine, CA

Chancellor's Professor of Mathematics. Pioneer in developing applications of geometric analysis. Made contributions to eigenvalues, harmonic function, and harmonic maps. Work with Yau on parabolic equations has become a basic tool for dynamic equations in geometry. Hamilton and Perelman made use of such ideas to solve spectacular problems in topology.

Tomasz Stanislaw Mrowka

Massachusetts Institute of Technology, Cambridge, MA

Professor of Mathematics. Contributed to differential geometry in low dimensions. Played a pivotal role in unraveling the connections between the topology, differential topology, and geometry of three- and four-dimensional manifolds.

Michael E. Taylor

University of North Carolina at Chapel Hill, Chapel Hill, NC

William R. Kenan, Jr. Professor of Mathematics. Made contributions to the theory of partial differential equations, especially with his work on diffraction of waves, convergence properties of eigenfunction expansions, and low regularity in nonlinear problems. Wrote a comprehensive treatment of the subject accessible to a wide mathematical audience.

Robert J. Zimmer

University of Chicago, Chicago, IL

President; Mathematician. Work on ergodic theory, Lie groups, and differential geometry has led to important applications. Provost of Brown University from 2002–2006. As an institutional leader, built partnerships and collaborations that extend the reach of science and technology and that apply multidisciplinary expertise to complex intellectual, social, and scientific issues.

New members Deborah Estrin (University of California, Los Angeles) and Philip Betancourt (Temple University)

Section 2: Physics

Persis Sydney Drell

Stanford University, Stanford, CA

Professor; Deputy Director, Stanford Linear Accelerator Center. Principal leader of the CLEO particle physics collaboration at Cornell during its most productive period. Developed techniques for precision studies of the interaction between heavy quarks, which inspired the creation of the next generation of accelerators, "B-Factories," at SLAC and KEK.

Deborah S. Jin

University of Colorado, Boulder, CO

Adjunct Professor; Fellow, National Institute of Standards and Technology and JILA. Worked on the realization and exploration of a novel quantum system, the degenerate Fermi gas of atoms. Created the first quantum degenerate gas in 1996 and the first Fermi condensate in 2004. In 2003, reported the first direct observation of a molecular Bose-Einstein condensate.

J. Michael Kosterlitz

Brown University, Providence, RI

Harrison E. Farnsworth Professor of Physics. Contributed to the development of theoretical physics. With David Thouless, in the 1970s, developed the theory of topological phase transitions. Two publications in the *Journal of Physics* in 1973–1974 laid the foundation of this field and have since been cited over 6,600 times.

Juan Martín Maldacena

Institute for Advanced Study, Princeton, NJ

Professor, School of Natural Sciences. Using string theory tools, with collaborators, clarified quantum properties of black holes. Applications of his 1997 proposal of the AdS/CFT conjecture, relating gauge theories to gravitational and string theories, range from the dynamics of black holes to quantum chromodynamics.

Venkatesh Narayanamurti

Harvard University, Cambridge, MA

Dean of Engineering and Applied Sciences; John A. and Elizabeth S. Armstrong Professor of Engineering and Applied Sciences; Professor of Physics. Using infrared photons and very high frequency phonons at low temperatures, and also through work involving ballistic electrons, has made contributions to our understanding of lattice vibrations and defects in solids.

Saul Perlmutter

University of California, Berkeley, Berkeley, CA

Professor of Physics. Leads the Supernova Cosmology Project. Cocredited with discovering that the expansion of the Universe is

accelerating. His group developed new ways to find and study distant supernovae for these cosmology measurements. Current work addresses the nature of the mysterious "dark energy" causing the Universe's acceleration.

John Henry Schwarz

California Institute of Technology, Pasadena, CA

Harold Brown Professor of Theoretical Physics. Founder of both supersymmetry and superstring theory. With collaborators, constructed the first supersymmetric model, proposed superstring theory as the basis for quantum gravity, and started the "first string revolution" by removing a long-standing obstacle, thereby catapulting strings to center stage.

Bruce Darrell Winstein

University of Chicago, Chicago, IL

Samuel K. Allison Distinguished Service Professor of Physics. Conceived of and led a series of K-mes-on experiments to elucidate the origin of the matter-antimatter asymmetry in nature. Work culminated in the unambiguous observation of a new type of matter-antimatter asymmetry, that in the K-meson decay process.

Section 3 : Chemistry

Héctor Daniel Abruña

Cornell University, Ithaca, NY

Emile M. Chamot Professor of Chemistry. Analytical chemist. Provided an atomic scale understanding of surface-liquid interface behavior during electrochemical processes using in situ X-ray studies (EXAFS, standing waves, surface diffraction) and metal monolayers on single crystal electrodes. Developed novel modified electrodes (e.g., with redox and photoactive dendrimers), molecular electronics, and electrocatalysts for fuel-cell applications.

Karl Frederick Freed

University of Chicago, Chicago, IL

Henry Gale Distinguished Service Professor of Chemistry ; Director, James Frank Institute. In quantum chemistry, laid the rigorous basis for semi-empirical theory. In polymer chemistry, elucidated phase changes and behavior of inhomogeneous systems. In molecular biology, found effective ways to simulate protein dynamics accurately and identify crucial contributors to structure.

Gregory Chung-Wei Fu

Massachusetts Institute of Technology, Cambridge, MA

Professor of Chemistry. Developed palladium and nickel catalysts for the formation of carbon-carbon bonds through cross-coupling reactions. Achieved couplings of challenging aryl chlorides and alkyl electrophiles, including asymmetric processes. Designed a range of enantioselective nucleophilic and transition-metal catalysts.

William L. Jorgensen

Yale University, New Haven, CT

Whitehead Professor of Chemistry. Pioneered computer modeling of chemical and biochemical systems. Key contributions include development of widely used energy functions for liquid water and bioorganic molecules, first simulations of organic reactions in solution, seminal studies of intermolecular interactions, and automation of molecular design with applications to discovery of anti-infective drugs.

James W. Jorgenson

University of North Carolina at Chapel Hill, Chapel Hill, NC

W. R. Kenan, Jr. Professor of Chemistry. Invented and developed capillary electrophoresis, the highest resolution, most time-efficient separations method known. Capillary electrophoresis is used to separate complex mixtures of biological origin, as in proteomics and metabolomics, and was the enabling experiment in DNA sequencing in the Human Genome Project.

Chaitan Khosla

Stanford University, Stanford, CA

Chair, Department of Chemical Engineering ; Wells H. Rauser and Harold M. Petiprin Professor in the School of Engineering ; Professor of Chemical Engineering, Chemistry, and Biochemistry. Made contributions to understanding and exploiting the programmable catalytic mechanisms of polyketide synthases. Accomplishments include methods for heterologous production of polyketides, genetically programmed biosynthesis of anthracyclines and polypropionates, and chemo-biosynthesis of new polyketides not readily affordable by synthetic or biological methods alone.

New members Christopher F. Edley, Jr. (Boalt Hall School of Law, University of California, Berkeley) and John Shattuck (John F. Kennedy Library Foundation)

Paul von Ragué Schleyer

University of Georgia, Athens, GA

Graham Perdue Professor of Chemistry. Discovered simple ways of preparing adamantane and other cage hydrocarbons. Conducted research on hydrogen bonding, carbocations, lithium, boron, and computational chemistry ; relationships of geometries, energies, magnetic properties, and bonding, especially of electron deficient and delocalized species. Discovered chemical structures involving planar hypercoordination ; borocarbon chemistry ; and in-plane, double, triplet state, Moebius, and three-dimensional aromaticity.

Joan Selverstone Valentine

University of California, Los Angeles, Los Angeles, CA

Professor of Chemistry and Biochemistry. Works at the interface of inorganic chemistry and biology. Pioneered the chemistry of superoxide anion and explained its significance to life processes, including the mechanism responsible for familial amyotrophic lateral sclerosis (Lou Gehrig's Disease).

Section 4 : Astronomy (including Astrophysics) and Earth Sciences

Donald E. Brownlee

University of Washington, Seattle, WA

Professor of Astronomy. Coinitiator and principal investigator of Stardust, a comet sample now returned to Earth and being analyzed. Studied the dust in the coma of comet Wild 2. Collected and analyzed interplanetary dust samples from comets and asteroids. Studies have given a better understanding of the origins of the solar system. Also studied oxygen isotopes in deep sea spherules.

Lars Hernquist

Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

Professor of Astronomy. Computational astrophysicist whose work identifies the physical processes important in the formation and evolution of galaxies. Application of his Tree SPH structure to code formation in the universe led to the discovery of the Cosmic Web.

Richard John O'Connell

Harvard University, Cambridge, MA

Professor of Geophysics. Theoretical solid-earth geophysicist. Work has enriched our under-

standing of plate tectonics, mantle convection and mixing, postglacial rebound, true polar wander, sedimentary basin formation, and the mechanics of composite materials, including polycrystalline and multiphase aggregates, porous and cracked solids, and partial melts. Physical insights into large-scale earth processes have permitted him to quantify complex processes.

Marcia J. Rieke

University of Arizona, Tucson, AZ

Professor of Astronomy. Author or coauthor of 200 peer-reviewed publications, including investigations of the Galactic Center and of the starburst phenomenon; cited in more than 6,500 articles. Led astronomical application of HgCdTe detector arrays. Deputy Principal Investigator, Near Infrared Camera and Multi-Object Spectrometer (NICMOS) on Hubble Space Telescope; Principal Investigator, Near Infrared Camera (NIRCam) for James Webb Space Telescope (JWST).

Joseph I. Silk

University of Oxford, Oxford, United Kingdom

Savilian Professor of Astronomy; Director of Beecroft Institute of Particle Astrophysics and Cosmology. First to compute the imprint of primeval galaxies on the Cosmic Microwave Background Radiation (CMB). This and subsequent work on the effects of density perturbations on the angular structure of the CMB helped usher in the modern era of precision cosmology.

Paul G. Silver

Carnegie Institution of Washington, Washington, DC

Staff Scientist. Established the use of shear-wave-splitting measurements as a tool for investigating mantle anisotropy and its implications for lithospheric structure and mantle dynamical flow patterns. Led the innovative use and collection of broadband seismic data. Contributed to our understanding of earthquakes and strain in fault zones.

Edward L. Wright

University of California, Los Angeles, Los Angeles, CA

Professor of Physics and Astronomy. Leader in the COBE team's discovery of anisotropy in the Cosmic Microwave Background. Member of the scientific teams for the Wilkinson Microwave Anisotropy Probe and the Spitzer Space Telescope. Principal Investigator on WISE, a NASA satellite to survey the infrared sky.

Klaus Wyrtki

University of Hawaii, Honolulu, HI

Professor Emeritus of Oceanography. Discovered the cause of El Niño. First to suggest a teleconnection between the westward trade winds over the equatorial Pacific and the flood of warm surface waters near Peru. Has demonstrated the ability to coax the essential features of ocean circulation from sparse data sets.

Section 5: Engineering Sciences and Technologies

Alexis T. Bell

University of California, Berkeley, Berkeley, CA

Professor of Chemical Engineering. Known for research on the mechanism and kinetics of catalyzed reactions. Work has led to the development and use of in situ spectroscopic techniques, and the application of modern theoretical techniques for determining the compositional/structural requirements of active sites and elucidating the elementary processes limiting catalyst activity/selectivity.

Arup K. Chakraborty

Massachusetts Institute of Technology, Cambridge, MA

Robert T. Haslam Professor of Chemical Engineering; Professor of Chemistry; Professor of Biological Engineering. Molecular engineer. Developed effective methods for using statistical mechanics, quantum mechanics, and molecular simulations to advance fundamental understanding of a variety of chemical and biological phenomena encountered in modern chemical engineering. Work on T cell biology represents a fruitful crossroad of the physical, life, and engineering sciences.

Bernard M. Gordon

Neurologica Corporation, Danvers, MA

Cofounder and Chief Executive Officer. Pioneered the first signal analog to digital conversion technology, digital air traffic control, and fetal monitoring systems as well as the first 3-D, multi-slice dual-energy explosive detection CT system in airports nationwide. Founder and Chairman of the Board, Analogic Corporation. Chairman of the Board of Directors, Lahey Clinic. Awarded the National Medal of Technology in 1986. Helped establish The Gordon Institute at Tufts University, The Gordon Prize for Educational Innovation at the National Academy of Engineering, and Professorships of Medical Imaging and of Engineering Practice at MIT.

Thomas J. R. Hughes

University of Texas at Austin, Austin, TX

Professor of Aerospace Engineering and Engineering Mechanics; Chair, Computational and Applied Mathematics. Made research contributions to and led the development of the Finite Element Method from its early heuristic phase to its current status as the most widely used computer simulation technology for the analysis of solids and fluids.

Alan Needleman

Brown University, Providence, RI

Florence Pirce Grant University Professor and Professor of Engineering. Work has broadened understanding of the deformation and failure of engineering materials, through application of modern computational methods. Has focused on nonlinear phenomena – large deformation, fracture, bifurcation, stability – and has introduced original strategies for material modeling, including the cohesive zone element for finite element analysis.

Arto Veikko Nurmikko

Brown University, Providence, RI

L. Herbert Ballou University Professor of Engineering and Physics. Research focuses on development of new semiconductor light sources and the use of laser-based techniques in fundamental condensed matter research and applied optical technologies in neuroscience. Accomplishments include development of the first blue/green semiconductor lasers, articulation of the dynamics of magnetic polarons, and demonstration of ultrafast optical switching of magnetization.

Michael Ortiz

California Institute of Technology, Pasadena, CA

Dotty and Dick Hayman Professor of Aeronautics and Mechanical Engineering. Developed efficient computational algorithms for solid mechanics, including

New members Stephen Emlen (Cornell University) and Thomas Hughes (University of Texas at Austin)

New members Henry Hansmann (Yale Law School) and Michael Taylor (University of North Carolina at Chapel Hill)

plasticity, collisions, and the theory and implementation of variation integration algorithms. One of the founders of the quasicontinuum method, a key method bridging atomistic and continuum scales, which links to theory and computational material microstructures, crack propagation, and fragmentation processes.

Stephen B. Pope

Cornell University, Ithaca, NY

Sibley College Professor of Mechanical and Aerospace Engineering. Pioneer of the probability density function methodology for turbulent reactive flows, and of Lagrangian studies of turbulent flows using direct numerical simulations. Developed dimension-reduction and storage-retrieval methodologies for computational combustion. Author of *Turbulent Flows*.

Section 6 : Computer Sciences (including Artificial Intelligence and Information Technologies)

Rodney Brooks

Massachusetts Institute of Technology, Cambridge, MA ; iRobot Corporation, Burlington, MA

Panasonic Professor of Robotics ; Chief Technology Officer. Advanced artificial intelligence and computer science through research, academic leadership, and commercialization. Research concerns the engineering of intelligent robots for unstructured environments and human intelligence. Has published on model-based computer vision, path planning, uncertainty analysis, robot assembly, active vision, micro-actuators, planetary exploration, representation, artificial life, and humanoid robots.

William James Dally

Stanford University, Stanford, CA

Willard R. and Inez Kerr Bell Professor of Engineering ; Chair, Department of Computer Science. Pioneered the interconnect technologies at the heart of high-performance computers, Internet routers, and storage-area networks. Developed parallel computing technologies, including stream-processing and message-driven computing. Built experimental systems and founded companies to realize these innovations. Has made several contributions to national security.

David J. DeWitt

University of Wisconsin-Madison, Madison, WI

John P. Morgridge Professor. Developed fundamental concepts for parallel database systems, put database performance evaluation on a firm footing with benchmark definitions, and implemented ideas in working systems.

Deborah Estrin

University of California, Los Angeles, Los Angeles, CA

Professor of Computer Science ; Director, Center for Embedded Networked Sensing. Made research contributions in the design of large-scale embedded sensor networks and environmental monitoring. Has contributed not only to a deeper understanding of these systems, but also to the development of tools and methods for such design. Has been an advocate and role model for women in computer science.

Pat Hanrahan

Stanford University, Stanford, CA

Canon USA Professor. Known for breadth and depth of work in computer graphics. Contributed to the Render Man® interface, which led to programmable graphics hardware and real-time "shaders" for games. Recognized with two Academy Awards.

Jon M. Kleinberg

Cornell University, Ithaca, NY

Professor of Computer Science. Research on network analysis helped form the foundation for the current generation of Internet search engines, and work on "small world" networks has advanced sociology as well as computer network design.

John Lasseter

Pixar and Disney Animation Studios, Emeryville, CA

Founding Member and Chief Creative Officer. Award-winning Director of many animated films, including *Toy Story*, *A Bug's Life*, *Toy Story 2*, and *Cars*. Award-winning Executive Producer of *Spirited Away* (US Production), *Monsters, Inc.*, *Finding Nemo*, and *The Incredibles*.

Eric Schmidt

Google Inc., Mountain View, CA

Chairman of the Board and Chief Executive Officer. Focuses on internal infrastructure for rapid growth and quality product development. As Chairman and Chief Executive Officer at Novell, led strategic planning, management, and technology. Before Novell, was Chief Technology Officer at Sun Microsystems, leading the development of Java.

David E. Shaw

D. E. Shaw Group, New York, NY

Chief Scientist. Computational biochemist, specializing in design of massively parallel supercomputers and algorithms and their application to biomolecular simulation. Helped found the field of computational finance, and built one of the world's largest hedge funds. Advisor on science and technology policy to the White House and Congress.

Robert J. Spinrad

Xerox Corporation, Palo Alto, CA

Vice President, Technology Strategy, Retired. Former Director of Xerox PARC, source of major innovations in personal computing, including graphic desktop, laser printing, and Ethernet. At Brookhaven, created earliest laboratory automation systems. Serves on Boards of California Council on Science and Technology and RAND Graduate School.

Class II: Biological Sciences

Section 1 : Biochemistry and Molecular Biology

Brenda L. Bass

University of Utah, Salt Lake City, UT

Distinguished Professor of Biochemistry ; Investigator, Howard Hughes Medical Institute. Made contributions to understanding double-stranded RNAs and the proteins that act on them in metazoan cells. Discovered the enzyme ADAR (adenosine deaminase acting on RNA), established its site-specific modification of mRNA, uncovered through structural studies its obligate cofactor inositol hexakisphosphate, and demonstrated its relationship to RNA interference.

Nancy L. Craig

Johns Hopkins University, Baltimore, MD

Professor of Molecular Biology and Genetics ; Investigator, How-

ard Hughes Medical Institute. Work has focused on defining macromolecular interactions that underlie the movement of mobile DNA "transposons" in bacteria and eukaryotes. Through genetics and biochemistry, is also studying how the host controls and reacts to transposition.

Douglas Hanahan

University of California, San Francisco, San Francisco, CA

Professor of Biochemistry. Introduced mouse models of cancer and synthesized the concepts of the angiogenic switch and cancer as an aberrant organ with a set of six acquired capabilities that define the multistage nature of cancer development and what it takes to be a tumor.

Barry Hirsh Honig

Columbia University, New York, NY

Professor of Biochemistry and Molecular Biophysics; Investigator, Howard Hughes Medical Institute. Contributed to understanding the physical-chemical basis of biochemical phenomena. Developed widely used methods for evaluating the electrostatic properties of macromolecules. Analyzed the thermodynamic determinants of fundamental biological processes. Devised predictive computational methods for relating sequence to macromolecular structure.

Haig H. Kazazian, Jr.

University of Pennsylvania, Philadelphia, PA

Professor of Genetics; Chair, Department of Genetics. First to demonstrate that transposable elements cause disease in man by insertional mutagenesis. Studies documented the existence of active retrotransposons in humans and mice, suggesting active retrotransposons in all mammals. Discovered that retrotransposon mobility leads to shuffling of exons and their flanking sequences, a finding of importance to our understanding of evolution.

New members Lily Jan (University of California, San Francisco) and Yuh Nung Jan (University of California, San Francisco)

Robert Andrew Lamb

Northwestern University, Evanston, IL

John Evans Professor of Biochemistry, Molecular Biology and Cell Biology; Investigator, Howard Hughes Medical Institute. Authority on genome organization, expression, and protein function of influenza virus and paramyxoviruses. Identified many unexpected protein coding strategies and elucidated the functional role of viral proteins in their cellular function, including the influenza virus proton-selective ion channel and the mechanistic basis of paramyxovirus-mediated membrane fusion.

Baldomero M. Olivera

University of Utah, Salt Lake City, UT

Distinguished Professor of Biology; Professor, Howard Hughes Medical Institute. Research on venomous cone snails and their peptide toxins resulted in the discovery of therapeutically important compounds and provided tools used by neuroscientists for characterizing ion channels and receptors. Early work with DNA ligase contributed to the recombinant DNA revolution in biology.

M. Thomas Record

University of Wisconsin-Madison, Madison, WI

Steenbock Professor in Chemical Sciences; John D. Ferry Professor of Chemistry and Biochemistry. Research has developed thermodynamic and kinetic/mechanistic principles of protein-DNA interactions and assembly processes, especially the use of solute, salt, and heat capacity effects to determine driving forces and driven conformational changes. Applications include characterization of large-scale conformational changes in transcription initiation by RNA polymerase, and in transcription factor binding in vitro and in vivo.

John Lee Spudich

University of Texas Houston Medical School, Houston, TX

Professor; Robert A. Welch Distinguished Chair in Chemistry. Discovered the first photosensory receptor in microorganisms (sensory rhodopsin-I); further showed microbial sensory rhodopsins to be widespread throughout archaeal, eubacterial, and eukaryotic species; and demonstrated that related proteins capture solar energy in oceans. Findings include seminal discoveries in membrane receptors and molecular mechanisms of phototransduction.

Robert M. Stroud

University of California, San Francisco, San Francisco, CA

Professor of Biochemistry and Biophysics; Professor of Pharmaceutical Chemistry. Discovered key mechanisms in biochemistry at the level of atomic structure and mechanism. Focused on understanding membrane protein structures and their function as channels and receptors, and targeting of their synthesis. Determined mechanisms of enzymes and uncovered principles for drug design aimed at protein structures.

Christopher M. Dobson (FHM)

University of Cambridge, Cambridge, United Kingdom

John Humphrey Plummer Professor of Chemical and Structural Biology. Contributed to understanding of how proteins fold to generate their biological function yet can misfold to generate disease. Developed and employed a wide range of novel experimental biophysical and computational techniques, with emphasis on nuclear magnetic resonance and its interpretation.

Avram Hershko (FHM)

Technion-Israel Institute of Technology, Haifa, Israel

Distinguished Professor of Biochemistry. Discovered the role of ubiquitin in intracellular protein degradation and defined the enzymatic machinery catalyzing ubiquitin-protein ligation. Ubiquitin-mediated degradation of regulatory proteins is now known to be critical to basic cellular processes such as cell division, signal transduction, transcription, and development. Awarded the Nobel Prize in 2004.

Louise N. Johnson (FHM)

University of Oxford, Oxford, United Kingdom

David Phillips Professor in Molecular Biophysics. Protein crystallographer. Worked on the recognition processes that control biological interactions. Provided a detailed description of the regulation of phosphorylase by protein phosphorylation and allosteric effectors, of various kinases by cyclins during the cell cycle, and of the interaction of ubiquinated proteins with the proteasome.

Section 2 : Cellular and Developmental Biology, Microbiology, and Immunology (including Genetics)

Bonnie Lynn Bassler

Princeton University, Princeton, NJ

Squibb Professor in Molecular Biology ; Investigator, Howard Hughes Medical Institute. Discovered interspecies communication (quorum sensing) in bacteria. Identified the universal cell-cell communication molecule (Al-2) and its synthase LuxS. Solved the structure of Al-2 bound to its receptor, LuxP, revealing that Al-2 contains boron – the first example of a biological role for boron.

Titia de Lange

Rockefeller University, New York, NY

Leon Hess Professor. Discovered major protein factors and structural elements that protect human chromosome ends (telomeres). Using molecular genetics, biochemistry, and physical methods, revealed critical insights into how mammalian telomeres protect against chromosome instability and act as a clock to time the aging process.

Alexander Dixon Johnson

University of California, San Francisco, San Francisco, CA

Professor of Microbiology and Immunology ; Professor of Biochemistry and Biophysics ; Vice Chair, Department of Microbiology and Immunology. Research concentrates on the control of gene expression and its evolution, and pathogenesis by *Candida albicans*, the most prevalent fungal pathogen of humans.

Alexandra Leigh Joyner

Memorial Sloan-Kettering Cancer Center, New York, NY

Member in the Developmental Biology Program, Sloan-Kettering Institute ; Courtney Steel Chair in Pediatric Cancer Research. Developed genetic approaches for studying mammalian development, including most recently a "Genetic Inducible Fate Mapping" technique for permanently marking cells based on their position or gene expression profile. Using these techniques has elucidated how genetic decisions made during embryonic development determine the morphology and function of the midbrain and cerebellum.

New members David DeWitt (University of Wisconsin-Madison) and James Jorgenson (University of North Carolina at Chapel Hill)

Terry Magnuson

University of North Carolina at Chapel Hill, Chapel Hill, NC

Sarah Graham Professor and Chair of Genetics ; Director, Carolina Center for Genome Sciences ; Program Director, Cancer Genetics, Lineberger Comprehensive Cancer Center. Researcher in the area of mouse developmental genetics. Work has led to an appreciation of the importance of genetic background in determining mutant phenotypes, and the development of novel technology for producing mutations in mice. Made contributions to identifying epigenetic mechanisms that regulate parent-of-origin expression at imprinted loci.

Jeremy W. Thorner

University of California, Berkeley, Berkeley, CA

Professor, Department of Molecular and Cellular Biology ; William V. Power Chair in Biology. Biochemist, molecular geneticist, and cell biologist. Conducted first isolation of a prohormone-processing endoprotease, and first isolation of a peptide-translocating ABC transporter. Performed isolation of the first MAP kinase and first phosphatidylinositol 4-kinase. Made contributions to G protein-coupled receptor and protein kinase signaling.

Susan R. Wessler

University of Georgia, Athens, GA

Regents Professor of Plant Biology. Provided a comprehensive picture of the interaction between transposable elements and plant genes and the impact of transposable elements on genome evolution. Pioneered the application of bioinformatic approaches to the analysis of transposable elements.

Junying Yuan

Harvard Medical School, Boston, MA

Professor of Cell Biology. Pioneered the understanding of the role of caspases in apoptosis. Identified the first caspases in both nematodes and mammals. Elucidated key pathways of apoptosis involving the cytoplasm, mitochondria, and endoplasmic reticulum. Transformed apoptosis from a descriptive phenomenon to a molecular mechanism of cellular suicide.

Section 3 : Neurosciences, Cognitive Sciences, and Behavioral Biology

Carlton Cuyler Hunt

University of North Carolina at Chapel Hill, Chapel Hill, NC

Professor Emeritus of Physiology. Neurophysiologist known for observations of the initiation and control of activity in sense organs of the mammalian body (e.g., motor control of the muscle spindle). Directed departments at University of Utah, Yale University, and Washington University in St. Louis.

Lily Y. Jan

University of California, San Francisco, San Francisco, CA

Professor of Physiology ; Investigator, Howard Hughes Medical Institute. Initiated molecular studies of potassium channels by cloning founding members of two large families of potassium channels. Led the elucidation of potassium channel diversity in neuronal dendrites and axon, revealed the underlying mechanisms, and explained how regulation of channel number and property contributes to neuronal signaling and plasticity.

Yuh Nung Jan

University of California, San Francisco, San Francisco, CA

Professor of Physiology ; Investigator, Howard Hughes Medical Institute. After the cloning of the *Shaker* gene, continued, with Lily Jan, to study potassium channels and to elucidate basic mechanisms of neural development. Besides characterizing cell fate specification by different proneural genes, pioneered the study of asymmetric cell division and the genetic dissection of dendrite morphogenesis.

Christof Koch

California Institute of Technology, Pasadena, CA

Lois and Victor Troendle Professor of Cognitive and Behavioral Biology and Professor of Computation and Neural Systems. Conducted research on the biophysics of computation, and on the neu-

New members Charles Langley (University of California, Davis) and Rosina Bierbaum (University of Michigan)

ronal basis of visual perception, attention, and consciousness. Together with Francis Crick, led the scientific study of consciousness. Latest book is *The Quest for Consciousness: A Neurobiological Approach* (2004).

Gail Mandel

Oregon Health and Science University, Portland, OR

Senior Scientist, Vollum Institute; Investigator, Howard Hughes Medical Institute. Contributed insights into silencing strategies in neuronal and organ development with the discovery of the REST repressor and the elucidation of a novel co-repressor machinery, including CoREST. Demonstrated a proteolytic control mechanism for REST as a mechanistic switch for regulating the transition from neuronal precursors to neuronal differentiation programs.

Helen J. Neville

University of Oregon, Eugene, OR

Professor of Psychology and Neuroscience; Lab Director, Brain Development Lab. Conducted basic research on the development and relative plasticity (i.e., enhanceability and vulnerability) of brain systems important in cognition. Discovered which systems are most changeable, and when, and the mechanisms that determine neuroplasticity. Currently is using this knowledge to implement interventions designed to improve cognition and educational outcomes in children.

Joshua Richard Sanes

Harvard University, Cambridge, MA

Professor of Molecular and Cellular Biology; Director, Center for Brain Science. Studies how connections form in the developing nervous system. Combining structural and molecular approaches, identified mechanisms that regulate this process. Also identified some of the ways in which synaptic connections fail to form or are not maintained properly in neurological diseases and aging.

Peter H. Schiller

Massachusetts Institute of Technology, Cambridge, MA

Dorothy W. Poitras Professor. Contributed to our understanding of the neural basis of visually guided eye movements by cortical and subcortical structures, the nature of ON and OFF and the midget and parasol channels of the visual system, and the functions of extastriate visual cortex.

Michael Petrides (FHM)

McGill University, Montreal, Quebec, Canada

Director, Cognitive Neuroscience Unit; James McGill Research Chair; Professor of Neurology and Neurosurgery. Demonstrated critical aspects of cognitive processing of various areas of the prefrontal cortex in both the human and the monkey brain. Provided an influential theoretical position on the functional organization of the prefrontal cortex and a comparative architectonic map of the human and the monkey prefrontal cortex.

Section 4: Evolutionary and Population Biology and Ecology

Jerry Allen Coyne

University of Chicago, Chicago, IL

Professor, Department of Ecology and Evolution. Main architect of the theory of the genetics of speciation. Developed the synthesis for the genetics of speciation – the genetics underlying the incompatibilities behind reproductive isolation.

Stephen T. Emlen

Cornell University, Ithaca, NY

Jacob Gould Schurman Professor of Behavioral Ecology. Authority on the evolution of vertebrate social behavior. Contributed to understanding bird migration, orientation, and communication. Provided insights into the evolution of cooperative behavior, mating systems, gender role-reversal, and family formation. Extended the relevance of animal studies to understanding human family dynamics.

John A. Endler

University of Exeter, Exeter, United Kingdom

Professor. Author of two books and numerous papers on evolution, centered on natural selection and speciation. Pioneered analysis of visual signaling systems in fish and birds to explain, in ecological and evolutionary terms, the enormous variety of color and pattern in nature.

Raymond B. Huey

University of Washington, Seattle, WA

Professor of Biology. Focused on the evolution of the sensitivity of physiological performance of ectotherms (e.g., insects, lizards) to temperature. A primary founder of the field of evolutionary physiology. Achieved integration of historically separate fields by exploring patterns of physiological evolution over different time scales. Established field of epidemiology of Himalayan mountaineering.

Peter Michael Kareiva

Nature Conservancy, Seattle, WA

Chief Scientist. Integrating theoretical, empirical, and conceptual approaches, sparked key innovations in ecology and conservation over the past twenty-five years. Leader in resource management agencies and conservation efforts internationally.

Charles Hunt Langley

University of California, Davis, Davis, CA

Professor of Genetics. Conducts research on the mechanisms and forces that shape genomic polymorphism and phenotypic variation among individuals and between species. Using *Drosophila* as a model system, characterized transposable elements as genomic parasites and investigated the genomic polymorphisms underlying quantitative genetic variation. Discovered and theoretically interpreted the strong reduction in DNA sequence polymorphism found in genomic regions of low crossing-over.

Jerry M. Melillo

Marine Biological Laboratory, Woods Hole, MA

Senior Scientist; Codirector, The Ecosystems Center. Developed the theory of how ecosystems are organized at large spatial scales (regional to global), and how it is applied to contemporary environmental problems. Leader in the management of the biosphere.

Mary Eleanor Power

University of California, Berkeley, Berkeley, CA

Professor of Integrative Biology. Combined biological and physical aspects to further understanding of food web dynamics in a spatial context. Extended understanding of how natural communities operate by emphasizing the connections between organisms in different, but adjacent, habitats.

Donald Ludwig (FHM)

University of British Columbia, Vancouver, British Columbia, Canada

Emeritus Professor. Applied mathematician. Provided the mathematical foundations that transformed adaptive ecosystem management into a quantitative discipline. Made contributions to scattering theory, stochastic population models, and fisheries management.

Nanako Shigesada (FHM)

Doshisha University, Kyotanabe, Japan

Professor. Developed mathematical models for the spatial spread of invaders and used them to predict the spatio-temporal pattern of invasion range and rate. Investigated how various environmental disturbances affect stability and biodiversity of ecosystems. Modeled spatio-temporal patterns generated by bacterial colonies.

Section 5: Medical Sciences (including Physiology and Pharmacology), Clinical Medicine, and Public Health

Nancy C. Andrews

Duke University School of Medicine, Durham, NC

Dean. Former Dean for Basic Sciences and Graduate Studies and George R. Minot Professor of Pediatrics at Harvard Medical School. Provided insight into iron metabolism. Employing molecular genetics, identified proteins that regulate the absorption of dietary iron and transport of iron from the intestine to other cells. Created mouse models of human hemochromatosis, a disorder of iron overload. Identified the role of the peptide hepcidin in redistributing iron in inflammatory states, explaining the anemia of chronic disease.

Bernard G. Forget

Yale University School of Medicine, New Haven, CT

Professor of Medicine and Genetics; Director, Hematology Training Program. Led the application of recombinant DNA technology in cloning and characterizing genes encoding human globin subunits and proteins of the red cell membrane. Advanced understanding of the pathogenesis of common inherited red cell disorders.

Barton Ford Haynes

Duke University School of Medicine, Durham, NC

Frederic M. Hanes Professor of Medicine; Director, Human Vaccine Institute. Discovered novel functional thymocyte and thymic epithelial molecules and developed techniques for curative allogeneic thymic transplantation in human DiGeorge syndrome. Discovered mechanisms of HIV-1 escape from neutralizing antibodies. Heads the Center for HIV/AIDS Vaccine Immunology, an international effort to develop an HIV-1 vaccine.

Michel Claudio Nussenzweig

Rockefeller University, New York, NY

Sherman Fairchild Professor of Immunology; Investigator, Howard Hughes Medical Institute. Showed that dendritic cells present antigens to activate effector T-cell responses and that DCs maintain peripheral T-cell tolerance in the steady state. Established that membrane antibodies regulate B-cell development and determined that the majority of newly arising B-cells are self-reactive.

Luis Fernando Parada

University of Texas Southwestern Medical Center, Dallas, TX

Southwestern Ball Distinguished Chair in Basic Neuroscience Research; Diana and Richard C. Strauss Distinguished Chair in Developmental Biology; American Cancer Society Research Professor. At the National Cancer Institute worked on the identification and characterization of Trk receptors as neurotrophin receptors. At University of Texas Southwestern Medical Center, continued studies of nerve cell survival and regeneration. Using mouse models, studies cancers of the nervous system, neural development, and spinal-cord injury.

New members from the University of North Carolina at Chapel Hill: Terry Magnuson, James Jorgenson, James Moeser, and Michael Taylor

Helen M. Piwnica-Worms

Washington University in St. Louis, St. Louis, MO

Professor of Cell Biology, Physiology, and Internal Medicine; Investigator, Howard Hughes Medical Institute. Transformed view of the cell-cycle clock and its intimate relationship with G2 checkpoint mechanisms. Insights form the basis of fundamental tenets of cell biology.

Allan G. Rosefield

Columbia University, New York, NY

Dean, Columbia University Mailman School of Public Health; DeLamar Professor of Public Health; Professor of Obstetrics and Gynecology. Known for work on women's equity, basic human rights, and reproductive health: the role of nonmedical personnel in prescribing contraceptives; the averting of maternal mortality and morbidity from pregnancy-related complications; and the prevention, treatment, and care of HIV-infected women and children in resource-poor settings.

Steven A. Schroeder

University of California, San Francisco, San Francisco, CA

Distinguished Professor of Health and Health Care. Pioneer in defining the issues concerning healthcare delivery and public health. Made contributions through personal scholarship and the initiatives that he introduced during twelve years as President of the Robert Wood Johnson Foundation, and, more recently, on tobacco control.

Moshe Oren (FHM)

Weizmann Institute of Science, Rehovot, Israel

Professor. Made contributions to research on the p53 tumor suppressor. Demonstrated that p53, but not cancer-associated derivatives thereof, can suppress malignant transformation. Showed that p53 can induce cell-cycle arrest and apoptosis in cancer cells. Identified Mdm2 as responsible for the ubiquitination and degradation of p53.

Peter J. Ratcliffe (FHM)

University of Oxford, Oxford, United Kingdom

Nuffield Professor of Medicine. Advanced understanding of vascular and erythropoietic systems. Contributions include dissection of pathways regulating hypoxia-inducible factor (a central angiogenesis regulator); the elucidation of its control mechanisms, its oxygen-induced modifications, and its ubiquitin-dependent degradation; and the perturbation of these processes in a hereditary cancer syndrome.

Class III: Social Sciences

Section 1: Social and Developmental Psychology and Education

Renée Baillargeon
University of Illinois at Urbana-Champaign, Champaign, IL
Alumni Distinguished Professor. Crafted original methods for assessing the conceptual competence of human infants. Revealed infants' understanding of the properties and behavior of inanimate objects, animals, and sentient beings. Enhanced understanding of the nature and course of children's cognitive development.

Aaron T. Beck
University of Pennsylvania, Philadelphia, PA
Professor Emeritus of Psychiatry. Developed the theory and practice of Cognitive Therapy, the world's fastest-growing psychotherapy, and demonstrated its efficacy for the treatment of depression, suicidal intent, and a wide range of other mental illnesses.

Stephen Elliott Fienberg
Carnegie Mellon University, Pittsburgh, PA
Maurice Falk University Professor of Statistics and Social Science. Contributed to the analysis of categorical data, including the use of log-linear models for large sparse multiway tables, capture-recapture problems, social networks and confidentiality and privacy, and to applications in diverse areas including biology, criminal justice, law, medicine, public health, public policy, and sociology.

Anthony G. Greenwald
University of Washington, Seattle, WA
Professor of Psychology. Provoked a resurgence of interest in the Self with his 1980 article on the "totalitarian ego." Made unconscious cognition and subliminal perception acceptable topics for scientific research. Developed the Implicit Association Test, which has enabled observation of one's own unconscious attitudes and revamped theoretical understanding of prejudice.

Janellen Huttenlocher
University of Chicago, Chicago, IL
William S. Gray Professor of Psychology; Program Chair for Developmental Psychology. Developed the unified exploration of cognitive development and adult cognition, with important discoveries in a variety of domains, including language, number, and space. Hierarchical coding model has been applied to space, time, and categories and is at the forefront of Bayesian thinking about cognition.

James H. Sidanius
Harvard University, Cambridge, MA
Professor of Psychology and of African and African American Studies. His Social Dominance Theory of intergroup discrimination takes into account the importance of maintaining an established status hierarchy as a potent determinant of the nature of intergroup relations, attitudes, and behavior. Social dominance perspective links social structural variables with psychological mechanisms at the individual level.

Linda B. Smith
Indiana University, Bloomington, IN
Chancellor's Professor; Professor of Psychological and Brain Sciences. Produced a formal theory of perceptual category development unifying developmental and adult research. Developed a model of linguistic effects on attention, having broad implications for developmental process and language disorders. Applied formal dynamical systems theory to the study of perception and action in infancy.

Section 2: Economics

David Cutler
Harvard University, Cambridge, MA
Dean for the Social Sciences; Otto Eckstein Professor of Applied Economics. Made empirical contributions in health economics and public finance. Documented how hospitals responded to Medicare's shift to prospective payment structure. Estimated the value of technological improvements in the health-care sector, particularly for cardiac care. Demonstrated how dynamic adverse selection can lead to the disappearance of some insurance markets.

New member Tomasz Mrowka (Massachusetts Institute of Technology) and family

Darrell Duffie
Stanford University, Stanford, CA
Dean Witter Distinguished Professor of Finance. Financial economist. Studies asset-pricing issues. Recent work analyzes the term structure of interest rates and default risk, especially under imperfect information. Contributed to understanding of incomplete securities markets and of the pricing of derivatives. Explored preferences under uncertainty as well as pricing of sovereign debt.

Glenn Ellison
Massachusetts Institute of Technology, Cambridge, MA
Gregory K. Palm Professor of Economics. Contributed to game theory and industrial organization. Provided models of learning through local interactions, novel theoretical and empirical methods for studying the geographic concentration of industries, and empirical studies of career-driven behavior of mutual-fund managers.

Kenneth R. French
Dartmouth College, Hanover, NH
Carl E. and Catherine M. Heidt Professor of Finance. Research focuses on the empirical analysis of stock returns and the financing decisions of corporations. Best known for finding that aggregate returns move predictably with the business cycle, and that average returns on individual stocks are explained by their sensitivities to small-stock indexes, value-stock indexes, and the market index.

N. Gregory Mankiw
Harvard University, Cambridge, MA
Robert M. Beren Professor of Economics. Macroeconomist. Made contributions to many areas, including consumption behavior, economic growth, and the micro-foundations of nominal rigidities. Contributed to the transmission of economic knowledge as a leading textbook author and as Chair of the President's Council of Economic Advisors.

Whitney K. Newey
Massachusetts Institute of Technology, Cambridge, MA
Carlton Professor of Economics. Made contributions to the theory of Generalized Method of Moment estimation and testing. With Ken West, developed a method for statistical inference with autocorrelated data. Contributed to efficient estimation in semiparametric models and to

nonlinear panel data with individual effects and nonparametric economic modeling.

Anna J. Schwartz

National Bureau of Economic Research, New York, NY

Research Associate. Research has focused on the role of money in business cycles and economic activity, financial regulation, financial stability, and the effect of price level stability, based on two centuries of research data.

Ernst Fehr (FHM)

Universität Zürich, Zürich, Switzerland

Professor; Director of the Institute for Empirical Research in Economics. Experimental and behavioral economist. Best known for highlighting the importance of reciprocity and fairness in markets and other social relationships. Codeveloped a canonical model of fairness that has stimulated recent theoretical and experimental research.

Section 3: Political Science, International Relations, and Public Policy

Stephen D. Ansolabehere

Massachusetts Institute of Technology, Cambridge, MA

Elting R. Morison Professor of Political Science. Has analyzed the effects of political institutions on electoral politics, including campaign advertising, the incumbency advantage in United States elections, the motivations of campaign contributions, and the impact of legislative reapportionment on policymaking in the states.

Robert S. Erikson

Columbia University, New York, NY

Professor of Political Science. Author of work in many areas of American politics, including economic voting, state politics, congressional elections, campaigns, turnout, polls, campaign finance, legislative districting, and policy representation. Pioneered the study of how macro changes in public opinion affect policymaking, and how macro changes in policy affect public opinion.

Arthur Lupia

University of Michigan, Ann Arbor, MI

Hal R. Varian Collegiate Professor of Political Science; Research Professor, Institute for Social Research. Author of books and articles on the role of information in political decision making. Work has included conceptualizing voter competence, specifying the conditions under which people trust others' statements, demonstrating the interactive effect of psychological and economic factors on political communication, and unpacking necessary and sufficient conditions for political coalitions to fail.

New members Joshua Sanes (Harvard University), Thomas Record (University of Wisconsin-Madison), and Haig Kazazian (University of Pennsylvania)

Richard G. Niemi

University of Rochester, Rochester, NY

Don Alonzo Watson Professor of Political Science; Director of Undergraduate Studies. Has written books and articles on voting, legislative districting, public opinion, legislative term limits. Work on civic education challenged the then-prevailing notion that high school government courses had no meaningful effect on students' knowledge. Work on electronic voting systems revealed weaknesses that could be improved with better design and more user testing.

Frances McCall Rosenbluth

Yale University, New Haven, CT

Damon Wells Professor of International Politics and Political Science. Reoriented the study of Japanese politics through the use of modern analytical techniques. Made contributions to the study of Japanese electoral politics, the bureaucracy, banking, regulation, and the economy. Also contributed to the comparative political economy of gender and height inequality.

James M. Snyder, Jr.

Massachusetts Institute of Technology, Cambridge, MA

Arthur and Ruth Sloan Professor of Political Science and Professor of Economics. Scholar of American politics, with theoretical work on vote-buying in legislatures, and empirical work on the incumbency advantage, the influence of political parties on candidates' positions and legislators' voting, the effects of reapportionment on legislative policymaking, and the impact of campaign spending.

John L. Sullivan

University of Minnesota, Minneapolis, MN

Regents' Professor; Arleen C. Carlson Chair in American Government. In political psychology, conducted work on electoral behavior, political alignment, public opinion, media effects, civic engagement, and political culture. Presented scholarship on political tolerance most recently in *With Malice Toward Some: How People Make Civil Liberties Judgments* (1995). Founder and coeditor of *Political Methodology*.

John Waterbury

American University of Beirut, Beirut, Lebanon

President; Professor of Political Studies. First President to reside in Beirut since 1984. As a scholar, including as Professor of Politics and International Affairs at Princeton's Woodrow Wilson School of Public and International Affairs, contributed to the study of the political economy of the developing world, especially the Middle East and North Africa.

Margaret Weir

University of California, Berkeley, Berkeley, CA

Professor of Sociology and Political Science. Focused on how institutions – including school systems, welfare states, urban governments, and constitutional arrangements like federalism – either mitigate or exacerbate inequalities based on race, ethnicity, and class, and on how institutions facilitate or impede the development of coalitions capable of affecting the distribution of human capacities.

Section 4: Law (including the Practice of Law)

Akhil Reed Amar

Yale Law School, New Haven, CT

Southmayd Professor of Law. Publications have been widely cited by scholars, judges, and lawmakers, including Supreme Court Justices in more than twenty cases. Has testified before Congress on a range of constitutional issues. Recipient of the American Bar Association's Silver Gavel Award for his book *America's Constitution: A Biography* (2005).

Christopher F. Edley, Jr.

Boalt Hall School of Law, University of California, Berkeley, Berkeley, CA

Dean; Professor of Law. Specialist in administrative law, public policy, and civil rights. Author of *Not All Black and White: Affirmative Action, Race and American Values* (1998) and *Administrative*

New members John Thornton (The Brookings Institution) and Richard Niemi (University of Rochester)

Law: Rethinking Judicial Control of Bureaucracy (1992). Government positions include Special Counsel to President on "mending" affirmative action and Associate Director for Economics and Government at Office of Management and Budget.

Henry Hansmann

Yale Law School, New Haven, CT

Augustus E. Lines Professor of Law. Scholar of economic enterprise. Invented the modern study of nonprofit organizations; helped found the new comparative study of institutions; and introduced historical tests into theoretical corporate scholarship.

Herbert Hovenkamp

University of Iowa College of Law, Iowa City, IA

Ben and Dorothy Willie Distinguished Professor of Law and History. Authority on antitrust law. Author of *Antitrust Law,* an 18-volume work. His book, *Enterprise and American Law, 1860 – 1880* (1991), a study of the social, political, and intellectual roots of American capitalism, received the Littleton-Griswold Prize of the American Historical Association in 1991. Latest book is *The Antitrust Enterprise: Principle and Execution* (2006).

Pamela Susan Karlan

Stanford Law School, Stanford, CA

Kenneth and Harle Montgomery Professor of Public Interest Law. Largely responsible for a new field of legal scholarship and pedagogy, the law of democracy. Authority on voting rights, electoral districting, and constitutional litigation. Lawyer for public causes and pro bono counsel for underrepresented interests. Former Commissioner, California Fair Political Practices Commission.

David Frank Levi

Duke University School of Law, Durham, NC

Dean. Positions and achievements include Chief Judge of the U.S. District Court for the Eastern District of California, Chair of the U.S. Judicial Conference Standing Committee on Rules of Practice and Procedure, a member of the Council of the American Law Institute, and coauthor of a standard work on federal trial practice.

Sandra Day O'Connor

Supreme Court of the United States, Washington, DC

Associate Justice, Retired. Between 1981 and 2006 served as a Justice of the United States Supreme Court. Opinions were influential in shaping the content of many important areas of constitutional law. Was the first female Justice in the Court's history.

Richard L. Revesz

New York University School of Law, New York, NY

Dean; Lawrence King Professor of Law. Scholar in environmental law, regulatory policy, and empirical study of judicial decision making. Uses law and economic and statistical methods in work that reshapes thinking. As Dean of the New York University School of Law, has demonstrated institutional leadership as well.

Rosalie Silberman Abella (FHM)

Supreme Court of Canada, Ottawa, Ontario, Canada

Judge. A judge since 1976, considered one of Canada's foremost experts on human-rights law. Has chaired the Ontario Labour Relations Board, Law Reform Commission, and the Royal Com-mission on Equality in Employment. Taught law at McGill University, judged the Giller Literary Prize, and graduated from the Royal Conservatory of Music in classical piano.

William Lawrence Twining (FHM)

University College London, London, United Kingdom

Emeritus Quain Professor of Juris-prudence. Has contributed to jurisprudence, evidence, legal education, and law and development in Africa. Best-known writings include an intellectual biography of Karl Llewellyn, development of Wigmore's principles of proof, and explorations of the roles of narrative in legal argumentation. Current work addresses the implications of globalization for the discipline of law.

Section 5: Anthropology, Archaeology, Sociology, Geography, and Demography

Philip P. Betancourt

Temple University, Philadelphia, PA

Laura H. Carnell Professor of Art History and Archaeology. Author of works on Minoan Crete and Aegean Bronze Age. Director of major interdisciplinary study of Minoan pottery. AIA Gold Medal recipient for lifetime of distinguished archaeological achievement. Executive Director of Institute for Aegean Prehistory (INSTAP) and of the INSTAP Study Center for East Crete, which he founded.

Tom D. Dillehay

Vanderbilt University, Nashville, TN

Distinguished Professor of Anthropology; Chair, Anthropology Department. South American archaeologist. Work changed views about the initial human colonization of the New World and the economic and social structures of the "First Americans." Published 15 books and more than 150 refereed journal articles.

Susan Gal

University of Chicago, Chicago, IL

Mae and Sidney G. Metzl Distinguished Service Professor of Anthropology, Linguistics, and Social Sciences. Made contributions to linguistic anthropology and the anthropology of Europe. Early work documented and theorized the socio-linguistic dynamics of plurilingualism in Central and Eastern Europe. Central linguistic anthropological student of the postsocialist transformation, especially of language and communicative patterns. Theorist of the cultural and ideological underpinnings of language-centered policy, practice, and scholarship.

David Harvey

The Graduate Center, City University of New York, New York, NY

Distinguished Professor of Anthropology. Social theorist in geography. Provided new conceptualizations of the relationship between political economic change and the processes of urbanization in advanced capitalist countries. Focuses on environmental justice, alternative modes of urbanization, and uneven geographical development within a globalizing world.

Elsa M. Redmond

American Museum of Natural History, New York, NY

Research Associate, Division of Anthropology. Combined archaeological and ethnohistorical research to elucidate the rise of social inequality, warfare, and chiefly conflict resolution in ancient Venezuela, Colombia, Ecuador, Panama, and Mexico. In four books, documented the alterna-

tive strategies that elevated native leaders in Central and South America.

Bruce Western

Harvard University, Cambridge, MA

Professor of Sociology. Uses advanced quantitative methods in social analysis. Early work was a comparative and historical analysis of trade-union movements in the Organization for Economic Cooperation and Development (OECD) countries after World War II. Played a leading role in studying the social and political consequences of incarceration and the dynamics of social inequalities in the United States.

David R. Williams

Harvard School of Public Health, Boston, MA

Florence Sprague Norman and Laura Smart Norman Professor of Public Health. Research reveals impacts of race, racism, and socioeconomic status, singly and in combination, on physical and mental health across the life course. Scholarship on health disparities also helped reshape academic epidemiology and public-health policies reflecting the subtleties of real and perceived discrimination.

Viviana A. Zelizer

Princeton University, Princeton, NJ

Lloyd Cotsen '50 Professor of Sociology. Authority on how economic activities affect the meaning of interpersonal relations, with particular emphasis on how the relationship between economic activity and personal life is changing or in dispute. Books, including *Pricing the Priceless Child* (1985) and *The Purchase of Intimacy* (2005), follow a progression with each new one relating to problems from its predecessor, yet taking a new approach that compels scholars to rethink their own presuppositions.

Gøsta Esping-Andersen (FHM)

Universitat Pompeu Fabra, Barcelona, Spain

Professor of Sociology. Early work centered on the political sociology of social democratic parties and electorates. Collaboration on an international welfare-state evolution project led to a focus on comparative social policies, welfare states, and political economy. Social inequality and life course constitute a third dominant theme in his work, resulting in two coauthored books and a number of journal articles.

Dan Sperber (FHM)

Centre National de la Recherche Scientifique, Paris, France

Research Director. Contributed one of the most cited theories of pragmatics, considered to be an essential component of linguistic theory. Proposed that Relevance Theory plays an essential role in the explanation of human reasoning. Book on the topic is a classic and has been translated into many languages, including French, German, Italian, Japanese, Korean, Malay, Portuguese, and Spanish.

Class IV: Humanities and Arts

Section 1: Philosophy and Religious Studies

Geoffrey Paul Hellman

University of Minnesota, Minneapolis, MN

Professor of Philosophy. Developed a modal-structural interpretation of mathematics, a variety of structuralism distinct from set theoretic and other Platonistic accounts. Examined varieties of constructive mathematics and apparent limitations in connection with scientific applications, arising especially in quantum mechanics and space-time physics. Pursued work on the significance of the Bell results in the foundations of quantum mechanics.

Terence Dwight Parsons

University of California, Los Angeles, Los Angeles, CA

Distinguished Professor of Philosophy and Linguistics. Contributed to formal semantics for natural languages; the relationship between quantified modal logic and essentialism; Meinong's meta-physics and semantics; Fregean semantics; the logic and metaphysics of indeterminate identity; and the history of medieval logic and semantics.

New members Morton Meyerson (2M Companies, Inc.) and W. James McNerney, Jr. (Boeing Company)

Robert B. Pippin

University of Chicago, Chicago, IL

Evelyn Stefansson Nef Distinguished Service Professor. Authored works about Kant's theory of form, Hegel's idealism, modernism as a philosophical problem, critical theory, and Henry James and modern moral life. In 2001, received the Mellon Foundation's Distinguished Achievement Award.

Stephen Schiffer

New York University, New York, NY

Professor of Philosophy; Chair, Department of Philosophy. Authored work on speaker-meaning, expression-meaning, mutual knowledge, reference, compositional semantics, propositional content (theory of pleonastic propositions), the relation of psychological and semantic facts to underlying physical and functional facts, the semantics of propositional-attitude reports, Descartes, ceteris paribus laws and psychological explanation, skepticism, vagueness and partial belief (psychological theory of vagueness).

Wilfried Sieg

Carnegie Mellon University, Pittsburgh, PA

Professor of Philosophy. Worked out proof theory of subsystems of classical analysis (second-order number theory) and arithmetic. Conducted conceptual analysis of the notions of human computability (Turing) and machine computability (Kolmogorov, Uspenskii, Gandy). Wrote a series of papers on the development of Hilbert's conception of foundations of mathematics, beginning with its origins in the work of Dedekind.

Michael J. Williams

Johns Hopkins University, Baltimore, MD

Krieger-Eisenhower Professor and Chair of Philosophy. Epistemologist. Explicated and defended the continuing interest of fundamental skeptical challenges to human knowledge while developing a distinctive diagnosis of how and why those challenges ultimately fail.

Mark L. Wilson

University of Pittsburgh, Pittsburgh, PA

Professor of Philosophy. Work has focused on the function of concept words, culminating in *Wandering Significance* (2006). Expert on the history and foundations of continuum mechanics and its influence on the philosophy of science. Wrote historical work on Descartes, Frege, Duhem, and Wittgenstein.

Jacques Brunschwig (FHM)

Université de Paris-I, Paris, France

Emeritus Professor of the History of Ancient Philosophy. French

expert in ancient philosophy. Played a leading part in the triennial meetings of the Symposium Hellenisticum, which has generated much of the best published work on Stoicism, Skepticism, and Epicureanism.

Timothy Williamson (FHM)

University of Oxford, Oxford, United Kingdom

Wykeham Professor of Logic. Work in analytical philosophy of language, logic, metaphysics, and epistemology constitutes an important contribution to these diverse branches of thought. Author of four volumes: *Identity and Discrimination* (1990), *Vagueness* (1994), *Knowledge and Its Limits* (2000), and *The Philosophy of Philosophy* (2007).

Section 2: History

David Gordon Blackbourn

Harvard University, Cambridge, MA

Archibald Carey Coolidge Professor of History. Produced work in many different areas of German history since 1750. Helped to undermine the reigning historical paradigm of Germany's "special path" or *Sonderweg*. Has since worked on modern mass politics, and written both a microhistory of popular religiosity and an environmental history of German waterlands.

Isabel Virginia Hull

Cornell University, Ithaca, NY

John Stambaugh Professor of History. Author of three books on German history, on subjects as diverse as military history and the history of sexuality. Prize-winning teacher, active in professional associations, and frequent lecturer in Germany and the United States.

Evelyn Fox Keller

Massachusetts Institute of Technology, Cambridge, MA

Professor of the History and Philosophy of Science. Work in the history and philosophy of twentieth-century biology and on gender and science has opened up new perspectives in the understanding of science. Books, translated into many languages, have attracted wide scholarly and public attention.

Sabine G. MacCormack

University of Notre Dame, Notre Dame, IN

Rev. Theodore M. Hesburgh C.S.C. Professor of Arts and Letters. Classicist and historian. Works on Late Antiquity to the Early Modern period, and has bridged the gap between cultures. Writes of Spanish colonizers and indigenous peoples of South America. Has been a Gauss Fellow, Mellon Fellow, Guggenheim Fellow, and a recipient of the Mellon Distinguished Achievement Award.

New members Steven Schroeder (University of California, San Francisco), Judith Shapiro (Barnard College), and Aram Chobanian (Boston University)

E. Roger Owen

Harvard University, Cambridge, MA

A. J. Meyer Professor of Middle Eastern History. Economic and political historian whose scholarship ranges across the entire Middle East and North Africa. Best known for his contributions to our understanding of the economic history of the Middle East since 1800. Author of the definitive biography of Lord Cromer.

Nell Irvin Painter

Princeton University, Princeton, NJ

Edwards Professor of American History, Emerita. Published numerous books, articles, reviews, and essays, most recently *Southern History Across the Color Line* (2002) and *Creating Black Americans* (2006). Former Director of Princeton's Program in African American Studies. President of the Southern Historical Association and President of the Organization of American Historians.

Peter C. Perdue

Massachusetts Institute of Technology, Cambridge, MA

T. T. and Wei Fong Chao Professor of Asian Civilizations and Professor of History. Reinterpreted the history of early modern China. His *China Marches West* (2005) examines the expansion of the Qing empire into inner Asia and its relationship to frontier studies, environmental history, and global imperialism.

Martin Jay Sherwin

George Mason University, Fairfax, VA

Professor. International expert on U.S. foreign policy in the cold-war era. Won the 2006 Pulitzer for Biography for *American Prometheus* and was a Pulitzer finalist in 1976 for *A World Destroyed*. Received NEH awards for documentary film on Igor Kurchatov.

David J. Weber

Southern Methodist University, Dallas, TX

Robert and Nancy Dedman Professor of History. Historian and authority on the Spanish-Mexican Borderlands in North America, the frontiers of the Spanish American empire, and the American Southwest. Author or editor of 21 books. Recipient of the highest awards that Spain and Mexico give foreigners. Founding Director of Clements Center for Southwest Studies at Southern Methodist University.

Aldo Schiavone (FHM)

Istituto Italiano di Scienze Umane, Firenze, Italy

Director and Full Professor. Directed the 7-volume Einaudi publication, *Storia di Roma*. Author of several books on Roman history and Roman law, among them *The End of the Past* (2001), as well as two books on contemporary Italian politics.

Section 3: Literary Criticism (including Philology)

Michael J. Colacurcio

University of California, Los Angeles, Los Angeles, CA

Distinguished Professor of English. Literary critic and historian of early American culture. Known for scholarship investigating the relationships between the major writers of Puritan New England and those of the American Renaissance, with particular attention to the influence of religious tradition and theological debate on intellectual history and works of literature.

Leo Damrosch

Harvard University, Cambridge, MA

Ernest Bernbaum Professor of English Literature. Interpreter of Samuel Johnson, Alexander Pope, and William Blake. Analyst of the intellectual and religious currents of Great Britain in the seventeenth, eighteenth, and nineteenth centuries. Biography of Jean-Jacques Rousseau was a finalist for the National Book Award.

John A. Goldsmith

University of Chicago, Chicago, IL

Edward Carson Waller Distinguished Service Professor of Linguistics and Computer Science. Pioneered the use of rich geo-

metric structures in the modeling of phonological structures in linguistics, beginning with work on autosegmental phonology in his dissertation and later in other publications. In more recent work, has focused on ways in which contemporary statistical learning theory can inform and advance our understanding of what the ultimate goal of linguistics is.

Robert Pogue Harrison

Stanford University, Stanford, CA

Professor of Italian ; Rosina Pierotti Professor in Italian Literature. Dante scholar. Author of a book on the *Vita Nuova* and two literary-philosophical studies – *Forests* (1992), a study of the role of the forest in Western imagination, and *The Dominion of the Dead* (2003), a study of the meaning of burial rites from the Greeks to the present – as well as a book published in French, *Rome, la pluie* (1994), and a forthcoming book, *Gardens : An Essay on the Human Condition*.

Lawrence G. Manley

Yale University, New Haven, CT

William R. Kenan, Jr. Professor of English. Author of books on the idea of convention and on the literature and culture of London, with a focus on the long Renaissance, but covering a range of information stretching from the Greek and Roman period to circa 1800. Currently working on Shakespeare and theater history.

Ivan A. Sag

Stanford University, Stanford, CA

Professor of Linguistics and Symbolic Systems. Syntactic and semantic theorist noted for work on many aspects of theoretical linguistics. Contributed to modern varieties of phrase structure grammar. Work has challenged mainstream syntactic theory by seeking integration and mutual illumination among diverse alternatives.

Debora Kuller Shuger

University of California, Los Angeles, Los Angeles, CA

Professor of English. Renaissance scholar and author of several books, including a study of the Renaissance Bible. Interests range from Tudor-Stuart devotional literature and biblical exegesis to legal history and political thought. Recent works include *Political Theologies in Shakespeare's England* (2001) and *Censorship and Cultural Sensibility* (2006).

Richard Sieburth

New York University, New York, NY

Professor of French and Comparative Literature. Ezra Pound critic ; scholar-editor (edited the new Library of America volume of Pound as well as the New Directions *Pisan Cantos*) ; translator and critic of major nineteenth-century French and German fiction and poetry, especially Gerard de Nerval, Mallarme, Holderlin, George Buchner, and Walter Benjamin. Frequent reviewer for *The Times Literary Supplement* and other major journals.

James Wood

Harvard University, Cambridge, MA ; The New Yorker, New York, NY

Professor of the Practice of Literary Criticism ; Staff Writer. Chief literary critic of *The Guardian* in London since 1992 and Senior Editor of *The New Republic* from 1996 – 2007. Reviews and essays have appeared in *The New York Times*, *The New Yorker*, *The New York Review of Books*, and *The London Review of Books*, where he is a member of the editorial board. Winner of the British Press Young Journalist of the Year Award in 1990.

Tzvetan Todorov (FHM)

Centre National de la Recherche Scientifique, Paris, France

Director Emeritus. Honors include the Jean-Jacques Rousseau Prize, Prix Européen de l'Essai, and Spinoza Lens Award. Work includes *The Fantastic : A Structural Approach to a Literary Genre* (1973), *Introduction to Poetics* (1981), *The Conquest of America* (1984), *Facing the Extreme : Moral Life in the Concentration Camps* (1996), *Imperfect Garden : The Legacy of Humanism* (2002), *Hope and Memory* (2004), and *The New World Disorder* (2005).

New members Kenneth Wallach (Central National-Gottesman, Inc.) and Norman Neureiter (American Association for the Advancement of Science)

Brian William Vickers (FHM)

University of London, London, United Kingdom

Distinguished Senior Fellow, School of Advanced Study. Known for scholarly work and literary criticism, focusing on classical rhetoric in English literature, the works of William Shakespeare, and Francis Bacon. Work includes *In Defence of Rhetoric* (1988), *Appropriating Shakespeare : Contemporary Critical Quarrels* (1994), *English Renaissance Literary Criticism* (1994), and *Shakespeare, Co-Author : A Historical Study of Five Collaborative Plays* (2004).

Section 4 : Literature (Fiction, Poetry, Short Stories, Nonfiction, Playwriting, Screenwriting)

Patricia Hampl

University of Minnesota, Minneapolis, MN

Regents Professor of English. First won recognition for *A Romantic Education*, a memoir about her Czech heritage, and *Virgin Time* (1992), an inquiry into contemplative life. Has written two collections of poems and *Spillville*, a meditation on Dvorak's summer in Iowa. Also author of *I Could Tell You Stories* (1999), *Blue Arabesque* (2006), and *The Florist's Daughter* (2007).

John Patrick Shanley

New York, NY

Playwright, screenwriter, and director. Awarded Oscar for Best Original Screenplay and Writers Guild of America Award for Best Screenplay Written Directly for the Screen for *Moonstruck* (1987). Received Pulitzer Prize for Drama, Drama Desk Award, and Tony Award for Best Play for *Doubt* (2005). Plays include *Danny and the Deep Blue Sea* (1983), *Savage in Limbo* (1984), *Beggars in the House of Plenty* (1991), and *Sailor's Song* (2004). Wrote several films, including *Alive* (1993) and *Congo* (1995), and wrote and directed *Joe Versus the Volcano* (1990).

John Banville (FHM)

Dublin, Ireland

Novelist, journalist. Served as editor and contributed to *The Irish Press*, *Irish Times*, and *The New York Review of Books*. Award-winning books include *Kepler* (1993), *Dr. Copernicus* (1993), *Birchwood* (1973), *The Book of Evidence* (1989), and *The Sea* (2005), for which he won the Man Booker Prize for Fiction.

Amos Oz (FHM)

Ben-Gurion University of the Negev, Be'er Sheva, Israel

Novelist, essayist, professor, and social activist. Most of his writing (25 works or more), spanning the years 1965 – 2005, has been translated from Hebrew into 35 languages and distributed in 30 countries. One of the leading figures in the Peace Now movement.

Section 5: Visual and Performing Arts – Criticism and Practice (including Art, Architecture, Sculpture, Music, Theater, Film, Dance)

Emanuel Ax
New York, NY

Pianist. Garnered seven Grammy Awards, three for recordings of duo recitals with cellist Yo-Yo Ma. Recordings of piano concertos by Beethoven, Chopin, Haydn, and Schoenberg also earned acclaim. In recent years has performed and recorded works by twentieth-century composers.

Lee Bontecou
New York, NY

Artist. Had her first solo exhibition in 1959, in New York City. In the early 1970s joined the faculty of Brooklyn College, City University of New York, and taught there until her retirement in 1991. Had first museum exhibition in 1968 at the Museum Boymans-van Beuningen in Rotterdam. In 2003 – 2004 a major retrospective of her work was presented at the Museum of Contemporary Art, Chicago; the Hammer Museum, Los Angeles; and the Museum of Modern Art, New York.

Madeline Harrison Caviness
Tufts University, Medford, MA

Mary Richardson Professor of Art History, Emerita. Scholar of European medieval art, and expert on glass painting and medieval women as viewers of art. Honorary President of the Union Académique Internationale. Recipient of both the John Nicholas Brown Prize and the Haskins Medal of the Medieval Academy of America.

Jacques d'Amboise
National Dance Institute, New York, NY

Founder. Classical ballet dancer. Started the National Dance Institute, an organization dedicated to inspiring children through the arts using dance as the catalyst. Recipient of The Mayor's Award for Arts & Culture (2004), People First Honoree – *People Magazine* (2002), The Arison Award (2002), the Heinz award (2001), *Dance Magazine* award (1999), the Kennedy Center Honors (1995), a 1990 MacArthur Fellowship, and numerous other awards.

Margot E. Fassler
Yale University, New Haven, CT

Robert Tangeman Professor of Music History. Holds joint appointments with the Institute of Sacred Music, the Department of Music, the School of Music, and Yale Divinity School. Winner of the Medieval Academy of America's Nicholas Brown Prize for the best first book on a medieval subject and of the American Musicological Society's Otto Kindeldey Award for the most distinguished work in musicology. Wrote, produced, and directed "Work and Pray: Living the Psalms with the Nuns of Regina Laudis" and "Joyful Noise: Psalms in Community." Most recent book is *Making History: The Virgin of Chartres and the Liturgical Framework of Time* (2007).

Spike Lee
40 Acres & a Mule Filmworks, Brooklyn, NY; New York University, New York, NY

Founder and Chairman; Artistic Director of the Graduate Film Program and Amy and Joseph Perella Chair. Filmmaker and director who approaches difficult subject matter of inner-city turmoil, race relations, and politics in films such as *Do the Right Thing* (1989), *Malcolm X* (1992), *4 Little Girls* (1997), and *Inside Man* (2006). Has also produced, written, and acted in many of his films.

Thomas W. Lentz
Harvard University, Cambridge, MA

Elizabeth and John Moors Cabot Director of the Harvard University Art Museums. Has been a curator at the Museum of the Rhode Island School of Design, the Los Angeles County Museum of Art, and the Freer Gallery of Art and the Arthur M. Sackler Gallery at the Smithsonian. Serves on several advisory committees, including the Museum of Fine Arts, Boston; the Council of American Overseas Research Centers Executive Committee; and the Japan Society Gallery Art Advisory Committee.

Errol Mark Morris
Fourth Floor Productions, Cambridge, MA

Filmmaker. Defined a new genre of documentary filmmaking. Works provide a window into the character and soul of individuals (*The Thin Blue Line*) or leaders who shape our destiny (*The Fog of War*). Received the Academy Award for Best Documentary Feature in 2003.

Jessye Norman
New York, NY

Opera and concert artist. Professional presentations include solo recitals, operatic portrayals, and appearances with symphony orchestras and chamber music groups with innovative programming of the classics, spirituals, jazz, and a fervent advocacy of contemporary compositions. Awards include Commandeur de L'Ordre des Arts et des Lettres, Legion d'Honneur, and the Kennedy Center Honor. Recognized for humanitarian and civic contributions.

Nicholas Beaver Penny
National Gallery of Art, Washington, DC

Senior Curator of Sculpture. Served as the keeper of the Department of Western Art at the Ashmolean Museum, Oxford, then as Clore Curator of Renaissance Painting at the National Gallery in London. Has published on Italian Renaissance painting, European sculpture, and the history of collecting.

Yvonne Rainer
University of California, Irvine, Irvine, CA

Distinguished Professor, Art Studio. Choreographer and filmmaker whose work in both disciplines often featured the medium's most fundamental elements rather than meeting conventional expectations. Recipient of a MacArthur Fellowship (1990) and numerous other awards.

Steve Reich
Pound Ridge, NY

Composer. Works embrace Western classical music as well as non-Western and American vernacular music, especially jazz. Compositions have been performed by major orchestras and ensembles throughout the world and have significantly influenced contemporary music, both classical and popular. Recipient of the Premium Imperial Award in Music (2006) and the Polar Prize of the Royal Swedish Academy of Music (2007).

Robert A. M. Stern
Yale University, New Haven, CT

Dean of the School of Architecture since 1998; Founder and Senior Partner, Robert A. M. Stern Architects. Practicing architect, teacher, and writer. Published books include five-volume series on New York City's architecture and urbanism.

Billie Tsien
Tod Williams Billie Tsien Architects, LLP, New York, NY

Architect. Teaches at Yale University. Projects include the Neurosciences Institute in La Jolla, California, the American Folk Art Museum in New York City, and the Reva and David Logan Center for Creative and Performing Arts at the University of Chicago (opening in 2011). Recipient of several National AIA Honor Awards.

Tod Williams
Tod Williams Billie Tsien Architects, LLP, New York, NY

Architect. Teaches at Yale University. Projects include the Neurosciences Institute in La Jolla, California, the American Folk Art Museum in New York City, and the Reva and David Logan Center for Creative and Performing Arts at the University of Chicago (opening in 2011). Recipient of several National AIA Honor Awards.

Wu Hung
University of Chicago, Chicago, IL

Harriet A. Vanderstappen Distinguished Service Professor in Chinese Art History; Director,

Center for Art of East Asia. Scholar of Chinese art and archaeology. Forged new ground in the critical assessment of contemporary Chinese art and cultural policy. Recent works include *Between Past and Future : New Photography and Video from China* (2004) and *Remaking Beijing : Tiananmen Square and the Creation of a Political Space* (2005).

Rem Koolhaas (FHM)

Office for Metropolitan Architecture, Rotterdam, The Netherlands

Principal. Cofounded the Office for Metropolitan Architecture (OMA). Published *Delirious New York, A Retroactive Manifesto for Manhattan* (1978). Book *S,M,L,XL* (1995) established connections between contemporary society and architecture. Heads AMO, the conceptual branch of OMA focused on social, economic, and technological developments and territories beyond architectural and urban concerns. Conducts *Project on the City* at Harvard University, where he is a professor.

Lino Tagliapietra (FHM)

Murano, Italy

Visual Artist. Glassblower and designer. Recognized as a master of "formal coherence," most notably in his glass vessels, spheres, and eel-shaped loops. In exhibits at museums throughout the United States, Europe, and East Asia, connects centuries of Venetian glass making with the dynamism of the American Studio Glass Movement.

Mitsuko Uchida (FHM)

London, United Kingdom

Pianist. Noted for her interpretations of Mozart, Beethoven, Chopin, and Schubert. Also recognized for her interpretations of Schoenberg. Artist-in-residence at the Cleveland Orchestra. Trustee of the Borletti-Buitoni Trust, which aims to help young concert artists develop and sustain international careers. Codirector of Marlboro Music in Vermont.

Class V: Public Affairs, Business, and Administration

Section 1: Public Affairs, Journalism, and Communications

Roger Angell

The New Yorker, New York, NY

Editor; Contributor (1962 – present). Dean of American writers about baseball. Has also written fiction, nonfiction, autobiography, and criticism. Essays have been collected in a series of books, including *The Summer Game* (1972), *Five Seasons* (1977), *Late Innings* (1982), *Season Ticket* (1988), *Once More Around the Park* (1991), *Game Time* (2003), and *Let Me Finish* (2006). Recipient of the George Polk Award for Commentary and the Authors Guild Award for Distinguished Service to American Letters.

Rosina M. Bierbaum

University of Michigan, Ann Arbor, MI

Dean, School of Natural Resources and Environment; Professor of Natural Resources and Environmental Policy. Known for design of integrated assessments to inform national environmental policy. At the Office of Technology Assessment, and as Associate Director of the Office of Science and Technology Policy in the White House, led analyses underpinning policy for acid rain, stratospheric ozone depletion, climate change, and energy strategy.

Albert A. Gore, Jr.

Generation Investment Management U.S. LLP, Washington, DC

Partner; Chairman. House Representative from Tennessee's 4th District (1977 – 1985); Senator (1985 – 1993); 45th U.S. Vice President. Environmental activist and author of *Earth in the Balance : Ecology and the Human Spirit* (1992) and *An Inconvenient Truth : The Planetary Emergence of Global Warming and What We Can Do About It* (2006). Member of the board of directors of Apple Computers; Cofounder and Chairman of *Current* (a youth oriented interactive cable network); Senior Advisor to Google.

New member Joan Selverstone Valentine (University of California, Los Angeles)

Aryeh Neier

Soros Foundation and the Open Society Institute, New York, NY

President. Was Executive Director of Human Rights Watch. Before that, served with the American Civil Liberties Union, including eight years as National Director. Played a leading role in the establishment of an international tribunal to prosecute those responsible for war crimes and crimes against humanity in Yugoslavia and conducted investigations of human-rights abuses in more than 40 countries. Most recent book is *Taking Liberties : Four Decades in the Struggle for Rights* (2003).

Norman P. Neureiter

American Association for the Advancement of Science, Washington, DC

Director, Center for Science, Technology and Security Policy. First Science and Technology Adviser to a U.S. Secretary of State, Madeleine Albright and Colin Powell (2000 – 2003). Joined the U.S. Foreign Service in 1965, and in 1967 became the first U.S. Science Attaché in Eastern Europe. From 1969 – 1973, served as International Affairs Assistant in the White House Office of Science and Technology. Subsequently became Vice President of Texas Instruments Asia, based in Japan.

William K. Reilly

Aqua International Partners LP, San Francisco, CA

President and Chief Executive Officer; Founding Partner. As Administrator of the Environmental Protection Agency (1989 – 1993), advocated for the "cap and trade" program under the Clean Air Act of 1990. Cochair of the National Commission on Energy Policy; Chairman, Nicholas Institute for Environmental Policy Solutions at Duke University. Past President of The Conservation Foundation (1973 – 1989) and the World Wildlife Fund (1985 – 1989); former Chairman of the World Wildlife Fund Board of Directors (2000 – 2006).

James E. Risen

New York Times, Washington, DC

Investigative Correspondent. In 2006 won both the Pulitzer Prize for National Reporting and the Goldsmith Prize for Investigative Reporting for reports that disclosed the existence of the National Security Agency domestic eavesdropping program. Author of *State of War : The Secret History of the CIA and the Bush Administration* (2006) and coauthor of *The Main Enemy : The Inside Story of the CIA's Final Showdown with the KGB* (2004).

Alice Waters

Chez Panisse Foundation and Chez Panisse, Berkeley, CA

Founder and Director; Chef and Owner. Committed to sustainable community agriculture and good, clean, and fair food. Opened Chez Panisse in 1971 and created the Chez Panisse Foundation in 1996 to help underwrite cultural and educational programs that demonstrate the transformative power of growing, cooking, and sharing food. Received numerous awards, including *Bon Appetit*'s Lifetime Achievement Award (2000) and the James Beard Humanitarian Award (1997). Visiting Dean at the French Culinary Institute, an Honorary Trustee of the American Center for Food, Wine and the Arts in Napa, and a Board Mem-

ber of the San Francisco Ferry Plaza Farmers Market. Most recent publication is *The Art of Simple Food: Notes, Lessons, and Recipes from a Delicious Revolution* (2007).

Murray L. Weidenbaum

Washington University in St. Louis, St. Louis, MO

Mallinckrodt Distinguished University Professor. Honorary Chairman, Weidenbaum Center on the Economy, Government and Public Policy. Former Chair of the Council of Economic Advisers. Focused national attention on the need to reform the government regulation process and participated in the resulting reforms. Analyzed the defense-industry relationship and advocated changes in government policy toward the defense industry. Founded the Weidenbaum Center on the Economy, Government and Public Policy at Washington University, and served as its director for 25 years.

Section 2: Business, Corporate, and Philanthropic Leadership (Private Sector)

Frank A. Bennack, Jr.

Hearst Corporation, New York, NY

Chairman of the Executive Committee; Vice Chairman of the Board. Corporate, civic, and philanthropic leader. Chief Executive Officer of the Hearst Corporation from 1979 to 2002. Trustee of the Hearst Family Trust and Director of the Hearst Foundation. Managing Director of the Metropolitan Opera; Chairman of the Museum of Television and Radio; Chairman of the Lincoln Center for the Performing Arts; and Vice Chair of the Board of Trustees, New York-Presbyterian Hospital.

Michael R. Bloomberg

New York, NY

108th Mayor of the City of New York. Funded relief programs for victims of domestic violence; sponsored the Children's Health Fund's Mobile Medical Unit; and supported construction of athletic fields at high schools throughout the five boroughs. Served on the boards of numerous civic, cultural, educational, and medical institutions, including the High School for Economics and Finance; the Lincoln Center for the Performing Arts; the Metropolitan Museum of Art; the Police & Fire Widows' & Children's Benefit Fund; S.L.E. (Lupus) Foundation; and Prep for Prep.

Donald Bren

Irvine Company, Newport Beach, CA

Chairman of the Board. As master planner, builder, and real-estate investor, created communities, powered economic growth, and focused resources on creative approaches to education and conservation – including vast open-space preservation and species protection.

Alan Mark Dachs

Fremont Group, San Francisco, CA

President and Chief Executive Officer. Member of the Board of Directors of Bechtel Group, Inc., and the S.D. Bechtel, Jr. Foundation. Charter Trustee and Chair Emeritus of the Board of Trustees at Wesleyan University. Trustee of The Brookings Institution and The Conference Board and member of the Corporation Visiting Committee for the Engineering Systems Division of MIT.

Lawrence K. Fish

RBS America and Citizens Financial Group, Inc., Boston, MA

Chairman. Director of The Royal Bank of Scotland Group and Textron Inc. Past Director of The Federal Reserve Bank of Boston. Trustee of the MIT Corporation and The Brookings Institution. Chair of multiple capital campaigns for community service organizations, including Rosie's Place, The Vietnamese Community Center, and the Codman Square Community Health Center.

Norman B. Leventhal

Beacon Companies, Boston, MA

Cofounder. Created The Beacon Companies (1946) and spin-off Beacon Properties Corporation, a Boston-based developer and manager of office buildings, housing, and hotels. Known in Boston for civic endeavors and major development projects, including Rowes Wharf, the renovation of South Station, and One Post Office Square – all of which have helped spark an urban revival.

New member Robert Spinrad (Xerox Corporation)

W. James McNerney, Jr.

Boeing Company, Chicago, IL

Chairman; President; and Chief Executive Officer. Previous Chairman of the Board and Chief Executive Officer of 3M. Former executive for the General Electric Company. Member of the Boeing Board of Directors since 2001. Member of the Procter & Gamble Board of Directors and the Northwestern University Board of Trustees. Chair of the U.S.-China Business Council. Serves on the World Business Council for Sustainable Development, The Business Roundtable, and The Business Council. Member of The Field Museum Board of Trustees in Chicago.

Morton H. Meyerson

2M Companies, Inc., Dallas, TX

Chairman and Chief Executive Officer. Former Chief Executive Officer of Electronic Data Systems (1966 – 1986) and Perot Systems (1992 – 1998). Currently a Director of ENSCO International, Inc., the Dallas Symphony Orchestra, and the MHM Family Tzedakah Fund. Past nonprofit affiliations include National Park Foundation, Texas National Research Laboratory SSC Commission Chair, Japan Society USA, Dallas Museum of Art, and Harry Ransom Center for Humanities Studies at the University of Texas, Austin.

Arthur Rock

Arthur Rock & Company, San Francisco, CA

Principal. Pioneer in the venture-capital industry. Served as Chairman of the Board and Chairman of the Executive Committee of Intel; and as Chairman of the Board of Scientific Data Systems. Held board positions at Apple; Teledyne, Inc.; Xerox; Argonaut Insurance; and AirTouch. Supports the California Institute of Technology, the San Francisco Museum of Modern Art, and the San Francisco Opera. President of the BASIC Fund. Member of the Board of the Children's Scholarship Fund and the Bay Area branch of Teach for America.

John L. Thornton

The Brookings Institution, Washington, DC

Chairman of the Board. Professor and Director of Global Leadership, Tsinghua University, Beijing. Retired as President and Co-Chief Operating Officer of the Goldman Sachs Group in 2003. Director of Intel since 2003 and Chairman of the Finance Committee of the Board. Director of the Ford Motor Company, News Corporation, and the Pacific Century Group, Inc. Endowed the John L. Thornton China Center at Brookings. Director or Trustee of the Asia Society, the China Institute,

the Eisenhower Fellowships, Morehouse College, and the Tsinghua University School of Economics and Management.

Kenneth L. Wallach

Central National-Gottesman, Inc., Purchase, NY

Chairman, President, and Chief Executive Officer. Runs a privately owned pulp and paper distribution business with global operations. Involved in philanthropic activities at Harvard University and in the New York City community. Serves as a Trustee of the American Museum of Natural History; a Director of the National Book Foundation and the 92nd St. Y; and a member of the Council on Foreign Relations.

Section 3: Educational, Scientific, Cultural, and Philanthropic Administration (Nonprofit Sector)

Aram V. Chobanian

Boston University, Boston, MA

President Emeritus; University Professor; and John I. Sandson Distinguished Professor of Health Sciences. Established the connection between hypertension and accelerated vascular disease, including atherosclerosis. Led the Joint National Commission on Detection, Evaluation and Treatment of High Blood Pressure, which developed national healthcare guidelines for hypertension. President ad interim, Boston University (2003 – 2005), President (2005 – 2006). As Dean of the School of Medicine, Provost, and President, built and expanded research programs and brought stability to the governance of the university.

Michael Vincent Drake

University of California, Irvine, Irvine, CA

Chancellor. Former University of California Vice President for Health Affairs (2000 – 2005) and Professor of Ophthalmology and Associate Dean at the University of California, San Francisco School of Medicine. Elected to the Institute of Medicine; received the AAMC Herbert Nickens Award in recognition of his career-long efforts to promote social justice in medical education.

James Moeser

University of North Carolina at Chapel Hill, Chapel Hill, NC

Chancellor. Champion of greater accessibility to higher education. Has overseen enhancements to the undergraduate program and the physical transformation of the campus. Concert organist. Has been Dean of Pennsylvania State University's College of Art and Architecture; Vice President for Academic Affairs and Provost at the University of South Carolina; and Chancellor of the University of Nebraska-Lincoln.

George Ranney

Chicago Metropolis 2020, Chicago, IL

President and Chief Executive Officer. Leads the engagement of the Chicago business community in the city's future. Chair and Chief Executive Officer of Prairie Holdings Corporation, a firm that is developing Prairie Crossing, a nationally recognized conservation community in the Chicago area. Served in various capacities as Vice President for Raw Materials and General Counsel for Inland Steel Industries. Senior Counsel to the law firm of Mayer, Brown, Rowe and Maw. Chairman of the University of Chicago's Board on Civic Affairs and Board Member of the MacArthur Foundation.

Judith R. Shapiro

Barnard College, New York, NY

President. Cultural anthropologist. Has done research on gender differences. Enhanced Barnard's academic reputation by launching innovative and interdisciplinary academic programs, tripling sponsored research by faculty, and strengthening its technological capacity. Provost of Bryn Mawr College from 1986 – 1994. Past President of the American Ethnological Society, Fellow of the Center for Advanced Study in the Behavioral Sciences, and Member of the American Philosophical Society.

New members James Risen (*New York Times*) and Dean Baquet (*New York Times*)

John Shattuck

John F. Kennedy Library Foundation, Boston, MA

Chief Executive Officer. Former Executive Director of the American Civil Liberties Union's Washington office (1976 – 1984); Vice President of Harvard under Presidents Bok and Rudenstine; Assistant Secretary of State for Democracy, Human Rights and Labor in the Clinton Administration; and U.S. Ambassador to the Czech Republic (1998 – 2000).

Stephen Stamas

American Assembly, New York, NY

Chair. Former Vice President of Exxon Corporation. Served in the U.S. Bureau of the Budget and other areas of the federal government. Other public-service roles include Chairman, Marlboro School of Music; Cochairman, American Trust for the British Library; Trustee, Nasher Foundation and Nasher Sculpture Center; Trustee Emeritus, the New York Philharmonic, where he was President from 1984 – 1989 and Chairman from 1989 – 1996; Director-Emeritus, Lincoln Center; and former Member and President of the Board of Overseers, Harvard University.

Donald Mitchell Stewart

University of Chicago, Chicago, IL

Visiting Professor, The Harris School of Public Policy Studies. As former President of Spelman College, increased its endowment and raised its academic rank. As Chief Executive Officer of the College Board, restored confidence in the SAT after years of controversy over cultural bias by instigating carefully calibrated recognition of ethnic and income variables. As President of the Chicago Community Trust, augmented the foundation's encouragement of marginal, underserved, and experimental community enterprises.

Remembrance

Photo by Schecter Lee

William T. Golden

William T. Golden – visionary statesman, presidential advisor, and generous patron of science, culture, and civic life – passed away on October 6, 2007, at the age of 97. A Fellow of the Academy for nearly 25 years and the recipient of the Academy's Scholar-Patriot Award, he was the exemplar of what the Academy's founders – America's founding fathers – termed an engaged citizen.

Golden was a catalyst for the ideas and institutions that forged a new bond between science and government. His interest in science and technology dated from the age of 13 when he earned a radio-transmitting license and became a ham radio operator. Following graduation from the University of Pennsylvania, he entered the Harvard Business School; a year later, in the depths of the Depression, he became a security analyst on Wall Street. A Lieutenant Commander in the U.S. Navy during World War II, Golden demonstrated his skill as an inventor by developing a cyclic rate control device for anti-aircraft machine guns, used in the latter part of the war and patented for Golden by the Navy.

Service to the government, to the world of science and scholarship, and to the City of New York would become the hallmark of Golden's life and work. During his service as a naval officer, he decided that at war's end, he would spend half of his time on nonprofit activities. As he said in an interview for the Harry S. Truman Library, "I told lots of people I'm prepared to work on things that will be interesting and useful, without getting paid." His first opportunity came with the creation of the Atomic Energy Commission (AEC) in 1946. As Assistant to Commissioner Lewis L. Strauss, Golden established a wide range of contacts with scientists and government officials as they worked to build a research enterprise at universities and within the commission.

His experience at the AEC led to his appointment in 1950 as Special Consultant to the Director of the Bureau of the Budget, charged with conducting "a review of scientific research of military significance and of the organization of the government for the promotion of scientific activities generally." In a period of about six months, Golden met with 165 scientists and engineers from universities, industry, and government and with numerous nonscientific government officials. The results, sent to President Truman in the now-famous 400-page "Golden Memoranda," laid the foundation for the establishment of the Office of Scientific Advisor to the President and the Office of Science and Technology in the Executive Office of the President. Golden went on to coauthor and edit three books on science advising at the highest levels of government and subsequently served as a member of the second Hoover Commission.

Golden's interest in "things interesting and useful" was expressed in a lifetime of service to nearly a hundred of the nation's leading scientific, cultural, and educational organizations. Treasurer of the American Association for the Advancement of Science for 31 years, he made unparalleled contributions as a board member and trustee of the American Museum of Natural History, Barnard College, the Carnegie Institute of Washington, Central Park Conservancy, Mount Sinai Medical Center, and the New York Academy of Sciences. A dedicated environmentalist, he purchased Black Rock Forest, a 3,700-acre preserve near West Point, from Harvard University in 1989; placed the purchase money in an endowment; and formed a consortium of university and ecological organizations to protect the area in perpetuity. He even found time to complete a master's degree in biology at Columbia University at the age of 70.

The American Academy was honored to be the beneficiary of Golden's guidance and generosity throughout his years as a Fellow. Aware of the need to strengthen the Academy's membership within and beyond academe, he took an active role in nominating individuals from science, technology, business, and public affairs and in encouraging them to participate in the Academy's work. He also strongly supported the Academy's efforts to advance the humanities, including our recent efforts to develop a set of statistical indicators in the humanities, modeled after the National Science Foundation's *Science and Engineering Indicators*.

A charter member of the Academy Trust, Golden valued and upheld our historic mission to serve the nation and the world. His time and support were critical in shaping our plans and in developing a vision for the future. When the Academy presented its Scholar-Patriot Award to William Golden in 2001, the citation concluded: *We honor your conviction that devoting one's life to public service, to the world of learning, and to the great institutions of this country is the best way to perpetuate a democratic and civil society.*

Shortly before his death, Golden created the first endowed chair in the history of the Academy. On behalf of the Officers, Chair of the Academy Trust and Vice President Louis W. Cabot announced that Chief Executive Officer Leslie Berlowitz has been named to hold the chair, with a special mandate to develop projects that reflect Golden's broad interests in the sciences and the humanities and his desire to advance knowledge for the public good.

The Academy expresses its sincere condolences to his wife, Catherine; his daughters Sibyl and Pamela; and to all those touched by his grace, gentle humor, and wisdom. Friend, colleague, and mentor to generations of men and women, William T. Golden will be deeply missed. ■

Noteworthy

Select Prizes and Awards

Nobel Prizes, 2007

Economics
Leonid Hurwicz (University of Minnesota)

Eric S. Maskin (Institute for Advanced Study)

Roger B. Myerson (University of Chicago)

Chemistry
Gerhard Ertl (Fritz-Haber-Institut der Max-Planck-Gesellschaft)

Peace
Albert A. Gore, Jr. (Generation Investment Management U.S. LLP) and the Intergovernmental Panel on Climate Change (IPCC)

National Medal of Arts, 2007

N. Scott Momaday (University of Arizona)

Andrew Wyeth (Chadds Ford, PA)

National Humanities Medal, 2007

Richard Pipes (Harvard University)

Presidential Medal of Freedom, 2007

Gary S. Becker (University of Chicago)

Francis S. Collins (National Institutes of Health)

Other Awards

Kofi Annan (Alliance for a Green Revolution in Africa) was awarded by the John D. and Catherine T. MacArthur Foundation a prize for international justice.

William F. Baker (Educational Broadcasting Corporation) was inducted into the Management Hall of Fame by the National Academy of Television Arts & Sciences.

Sacvan Bercovitch (Harvard University) was awarded the Bode-Pearson Prize for outstanding contributions to American studies by the American Studies Association.

Brian J. L. Berry (University of Texas, Dallas) has received the Walter Isard Award for Scholarly Achievement.

Tom Brokaw (NBC News) was presented with the 2007 Andrus Award by the AARP.

Peter Brooks (Yale University) is among the recipients of The Andrew W. Mellon Foundation's Distinguished Achievement Awards.

Vinton G. Cerf (Google, Inc.) is among the recipients of the 2008 Japan Prize for Information Communication Theory and Technology.

Joan Didion (New York City) received the 2007 Medal for Distinguished Contribution to American Letters by the National Book Foundation.

Ronald Dworkin (New York University) was awarded the 2007 Holberg International Memorial Prize.

Thomas Eisner (Cornell University) is the recipient of the John J. Carty Award for the Advancement of Science, given by the National Academy of Sciences.

Anthony S. Fauci (National Institutes of Health) received the 2007 Mary Woodard Lasker Award for Public Service.

Leon Fleisher (Baltimore, MD) is among the recipients of the 2007 Kennedy Center Honors.

Robert Fogelin (Dartmouth College) has been awarded an Emeritus Fellowship by the Andrew W. Mellon Foundation.

Richard Franke (John Nuveen Company) received the Phyllis Franklin Award for Public Advocacy of the Humanities, given by the Modern Language Association.

William H. Gass (Washington University in St. Louis) is the recipient of the 2007 Saint Louis Literary Award.

Lawrence Gold (Somalogic, Inc.) is the recipient of the Lifetime Achievement Award, given by the Colorado BioScience Association.

Albert A. Gore, Jr. (Generation Investment Management U.S. LLP) is among the winners of the Quill Book Awards. *The Assault on Reason* won in history/current events/politics.

William V. Harris (Columbia University) is among the recipients of The Andrew W. Mellon Foundation's Distinguished Achievement Awards.

Stanley Hart (Woods Hole Oceanographic Institution) was awarded the Arthur L. Day Prize and Lectureship by the National Academy of Sciences.

Robert Hass (New York City) is the 2007 winner of the National Book Award in poetry, for *Time and Materials: Poems 1997 – 2005*.

Howard Hiatt (Brigham and Women's Hospital) received the 2007 Gustav O. Lienhard Award from the Institute of Medicine.

Gerald Holton (Harvard University) was awarded the 2008 Abraham Pais Prize for History of Physics, given by the American Physical Society.

Andrew P. Ingersoll (California Institute of Technology) has been awarded the 2007 Gerard P. Kuiper Prize by the American Astronomical Society.

Shirley Ann Jackson (Rensselaer Polytechnic Institute) is the recipient of the Vannevar Bush Award, given by the National Science Board.

Robert E. Kahn (Corporation for National Research Initiatives) is among the recipients of the 2008 Japan Prize for Information Communication Theory and Technology.

Rudolf Kalman (Eidgenössische Technische Hochschule Zürich) was awarded the Charles Stark Draper Prize, given by the National Academy of Engineering.

Ellsworth Kelly (New York City) is the recipient of the 2007 National Art Lifetime Achievement Award.

Thomas W. Laqueur (University of California, Berkeley) is among the recipients of The Andrew W. Mellon Foundation's Distinguished Achievement Awards.

Charles M. Lieber (Harvard University) is the recipient of the 2007 NBIC Award for Research Excellence in Nanotechnology.

Mary Lyon (Mammalian Genetics Unit, Medical Research Council) is among the recipients of the 2007 Lewis S. Rosenstiel Award for Distinguished Work in Basic Medical Science, given by Brandeis University.

Jean Mandler (University of California, San Diego) received the Distinguished Scientific Contribution Award from the American Psychological Association. Her book *The Foundation of Mind* received the American Psychological Association's Eleanor Maccoby Book Award and the Cognitive Developmental Society's Best Authored Book Award.

Cormac McCarthy (El Paso, TX) is among the winners of the Quill Book Awards. *The Road* won in the general fiction category.

Norman P. Neureiter (American Association for Advancement of Science) was awarded the Public Welfare Medal by the National Academy of Sciences.

Marjorie Perloff (Stanford University) was named Honorary Guest Professor at the Beijing Foreign Language University.

Alejandro Portes (Princeton University) is the recipient of the National Academy of Sciences Award for Scientific Reviewing.

Ronald Rivest (Massachusetts Institute of Technology) is the recipient of the 2007 Marconi Award.

David Rosand (Columbia University) received the Paul Oskar Kristeller Lifetime Achievement Award, given by the Renaissance Society of America.

Philip Roth (New York City) received the 2007 PEN/Faulkner Award for Fiction for *Everyman*.

Martin Scorsese (New York City) is among the recipients of the 2007 Kennedy Center Honors.

Stephen Shectman (Carnegie Institution of Washington) was awarded the 2008 Jackson-Gwilt Medal by the Royal Astronomical Society.

Noteworthy

Davor Solter (Max-Planck Institute of Immunobiology) is among the recipients of the 2007 Lewis S. Rosenstiel Award for Distinguished Work in Basic Medical Science, given by Brandeis University.

William Gilbert Strang (Massachusetts Institute of Technology) was awarded the Peter Henrici Prize by the Society for Industrial and Applied Mathematics.

Joanne Stubbe (Massachusetts Institute of Technology) received the National Academy of Sciences Award in Chemical Sciences.

Clifford H. Taubes (Harvard University) is the recipient of the National Academy of Sciences Award in Mathematics.

Pindaros Roy Vagelos (Far Hills, NJ) is the recipient of the Prix Galien Pro Bono Humanitarian Award.

Pauline Yu (American Council of Learned Societies) was awarded the William Riley Parker Prize by the Modern Language Association of America.

New Appointments

Peter Agre (Duke University) was named Director of the Johns Hopkins Malaria Research Institute.

Bruce Alberts (University of California, San Francisco) has been named Editor-in-Chief of *Science* magazine.

John L. Anderson (Illinois Institute of Technology) was named President of Illinois Institute of Technology.

George E. Andrews (Pennsylvania State University) has been elected President of the American Mathematical Society.

Bonnie Bassler (Princeton University) has been appointed to the Scientific Advisory Board of Cubist Pharmaceuticals, Inc.

Allan M. Brandt (Harvard University) has been named Dean of the Graduate School of Arts and Sciences at Harvard University.

Ralph L. Brinster (University of Pennsylvania) and Jonathan A. Epstein (University of Pennsylvania) have been named as heads of the Institute for Regenerative Medicine at the University of Pennsylvania.

Angus Deaton (Princeton University) has been elected President-Elect of the American Economic Association.

Persis Drell (Stanford University) has been appointed Director of the Stanford Linear Accelerator Center.

Catherine Dulac (Harvard University) has been appointed to the Scientific Advisory Board of the Allen Institute for Brain Science.

Mary Ann Glendon (Harvard Law School) has been named U.S. Ambassador to the Holy See.

Robert Grubbs (California Institute of Technology) has joined California's Green Chemistry Initiative Science Advisory Panel.

Donald L. Horowitz (Duke University) has been elected President of the American Society for Political and Legal Philosophy. He has also been appointed to the Secretary of State's Advisory Committee on Democracy Promotion.

Eric Jacobsen (Harvard University) has been appointed to the Scientific Advisory Board of Cubist Pharmaceuticals, Inc.

Jeffrey M. Leiden (Clarus Ventures) was elected to the Board of Directors of Millennium Pharmaceuticals, Inc. and named Managing Director of Clarus Ventures.

Arthur Levitt, Jr. (The Carlyle Group) was appointed to the Treasury Department's Advisory Committee on the Auditing Profession.

Barbara Liskov (Massachusetts Institute of Technology) was named Associate Provost for Faculty Equity at the Massachusetts Institute of Technology, a position she will share with Wesley Harris (Massachusetts Institute of Technology).

Luis F. Parada (University of Texas Southwestern Medical Center) was appointed to the National Advisory Neurological Disorders and Stroke Council of the NIH.

Carl H. Pforzheimer III (Carl H. Pforzheimer and Co.) was named Chairman of the Board of Trustees of the National Humanities Center.

Steven Rosenstone (University of Minnesota) has been named Vice President for Scholarly and Cultural Affairs for the University of Minnesota.

John E. Sexton (New York University) was elected Chair of the Board of Governors of the New York Academy of Sciences.

Choon Fong Shih (National University of Singapore) was named President of King Abdullah University of Science and Technology.

Charles Simic (University of New Hampshire) was named the 15th Poet Laureate of the United States.

Barry Trost (Stanford University) has joined California's Green Chemistry Initiative Science Advisory Panel.

Paul A. Volcker (New York City) was appointed to the Treasury Department's Advisory Committee on the Auditing Profession.

Select Publications

Poetry

John Ashbery (Bard College). *Notes from the Air : Later Poems*. Ecco, November 2007

David Bromwich (Yale University). *American Sonnets : An Anthology*. Library of America, October 2007

Robert Hass (New York City). *Time and Materials : Poems 1997 – 2005*. Ecco, October 2007

Robert Pinsky (Boston University). *Gulf Music*. Farrar, Straus & Giroux, October 2007

Jay Wright (Bradford, VT). *Music's Mask and Measure*. Flood Editions, July 2007 ; *The Guide Signs : Book One and Book Two*. Louisiana State University Press, December 2007

Fiction

Russell Banks (Princeton University). *The Reserve*. HarperCollins, January 2008

J. M. Coetzee (University of Adelaide, Australia). *Diary of a Bad Year*. Viking, January 2008

Nadine Gordimer (Johannesburg, South Africa). *Beethoven Was One-Sixteenth Black and Other Stories*. Farrar, Straus, & Giroux, November 2007

Nonfiction

Madeleine Albright (Washington, D.C.). *Memo to the President Elect : How We Can Restore America's Reputation and Leadership*. HarperCollins, January 2008

David Attenborough (Richmond, United Kingdom), Susan Owens, Martin Clayton, and Rea Alexandratos (all, Royal Collection, United Kingdom). *Amazing Rare Things : The Art of Natural History in the Age of Discovery*. Yale University Press, October 2007

David Attenborough (Richmond, United Kingdom). *Life In Cold Blood*. Princeton University Press, April 2008

Leo Beranek (Cambridge, MA). *A Life in Sound, Science, and Industry*. MIT Press, March 2008

James Earl Carter, Jr. (Carter Center). *Beyond the White House : Waging Peace, Fighting Disease, Building Hope*. Simon & Schuster, October 2007

Noam Chomsky (Massachusetts Institute of Technology) and David Barsamian (Alternative Radio, Boulder, CO). *What We Say Goes : Conversations on U.S. Power in a Changing World*. Metropolitan Books, September 2007

Peter Demetz (Yale University). *Prague in Danger : The Years of German Occupation, 1939 – 1945*. Farrar, Straus & Giroux, April 2008

E. J. Dionne, Jr. (Brookings Institution). *Souled Out : Reclaiming Faith and Politics after the Religious Right*. Princeton University Press, January 2008

Louis Dupré (Yale University). *Religion and the Rise of Modern Culture*. University of Notre Dame Press, March 2008

Donald Fanger (Harvard University), trans. and ed. *Gorky's Tolstoy and Other Reminiscences*. Yale University Press, March 2008

Drew Gilpin Faust (Harvard University). *The Republic of Suffering: Death and the American Civil War*. Knopf, January 2008

George Fredrickson (Stanford University). *Big Enough to Be Inconsistent: Abraham Lincoln Confronts Slavery and Race*. Harvard University Press, February 2008

Howard Gardner (Harvard University). *Five Minds for the Future*. Harvard Business School Press, April 2008

Henry Louis Gates, Jr. (Harvard University). *Finding Oprah's Roots: Finding Your Own*. Crown, January 2007

Henry Louis Gates, Jr. (Harvard University) and Gene Andrew Jarrett (University of Maryland), eds. *The New Negro: Readings on Race, Representation, and African American Culture, 1892 – 1938*. Princeton University Press, October 2007

Paul Guyer (University of Pennsylvania). *Kant's "Groundwork for Metaphysics of Morals:" A Reader's Guide*. Continuum, July 2007; *Knowledge, Reason, and Taste: Kant's Response to Hume*. Princeton University Press, January 2008

Stephen Hawking (University of Cambridge), ed. *A Stubbornly Persistent Illusion: The Essential Scientific Work of Albert Einstein*. Running Press, December 2007

Morton Keller (Brandeis University). *America's Three Regimes: A New Political History*. Oxford University Press, October 2007

Randall Kennedy (Harvard Law School). *Sellout: The Politics of Racial Betrayal*. Pantheon, January 2008

Laurence J. Kotlikoff (Boston University). *The Healthcare Fix: Universal Insurance for All Americans*. MIT Press, October 2007

Alan Krueger (Princeton University). *What Makes a Terrorist: Economics and the Roots of Terrorism*. Princeton University Press, August 2007

David Levering-Lewis (New York University). *Gold's Crucible: Islam and the Making of Europe*. W.W. Norton, January 2008

Jay A. Levy (University of California, San Francisco). *HIV and the Pathogenesis of AIDS*. ASM Press, March 2007

Anthony Lewis (Cambridge, MA). *Freedom for the Thought That We Hate: Tales of the First Amendment*. Basic Books, January 2008

Lewis Lockwood (Harvard University) and the Julliard String Quartet. *Inside Beethoven's Quartets: History, Performance, Interpretation* (book and CD). Harvard University Press, April 2008

George Mandler (University of California, San Diego). *A History of Modern Experimental Psychology*. MIT Press, January 2007

John Mearsheimer (University of Chicago) and **Stephen Walt** (Kennedy School of Government, Harvard University). *The Israel Lobby and U.S. Foreign Policy*. Farrar, Straus & Giroux, September 2007

N. David Mermin (Cornell University). *Quantum Computer Science: An Introduction*. Cambridge University Press, September 2007

Toni Morrison (Princeton University). *What Moves at the Margin: Selected Nonfiction*. University Press of Mississippi, April 2008

Bill Moyers (Public Affairs TV, Inc.). *Moyers on Democracy: Speeches, 2004 – 2007*. Doubleday, February 2008

Gary Nash (University of California, Los Angeles) and Graham Russell Gao Hodges (Peking University/Colgate University). *Friends of Liberty: A Tale of Three Patriots, Two Revolutions, and the Tragic Betrayal that Divided a Nation*. Basic Books, April 2008

Martha Nussbaum (University of Chicago). *Liberty of Conscience: In Defense of America's Tradition of Religious Equality*. Basic Books, April 2008

Nicholas Penny (National Gallery of Art). *National Gallery Catalogues: The Sixteenth-Century Italian Paintings, Volume II: Venice, 1540 – 1600*. Yale University Press, February 2008

Renzo Piano (Genova, Italy). *Renzo Piano Museums*. Monacelli Press, October 2007

Richard A. Posner (U.S. Court of Appeals, Seventh Circuit). *How Judges Think*. Harvard University Press, April 2008

David Remnick (The New Yorker). *Secret Ingredients: The 'New Yorker' Book of Food and Drink*. Random House, November 2007

Pierre Rosenberg (Académie Française) and **Keith Christiansen** (Metropolitan Museum of Art). *Poussin and Nature*. Yale University Press, March 2008

Silvan Schweber (Brandeis University). *Einstein and Oppenheimer: The Meaning of Genius*. Harvard University Press, April 2008

Richard Sennett (New York University/London School of Economics). *The Craftsman*. Yale University Press, March 2008

Charles M. Taylor (Northwestern University). *A Secular Age*. Belknap Press/Harvard University Press, September 2007

Anthony Vidler (Cooper Union). *Histories of the Immediate Past: Inventing Architectural Modernism*. MIT Press, March 2008

James D. Watson (Cold Spring Harbor, NY). *Avoid Boring People: Lessons from a Life in Science*. Knopf, September 2007

Gary Wills (Northwestern University). *Head and Heart: American Christianities*. Penguin Press, October 2007; *What the Gospels Meant*. Viking, February 2008

M. Norton Wise (University of California, Los Angeles), Angela N. H. Creager and Elizabeth Lunbeck (both, Princeton University), eds. *Science Without Laws: Model Systems, Cases, Exemplary Narratives*. Duke University Press, October 2007

Gordon S. Wood (Brown University). *The Purpose of the Past: Reflections on the Uses of History*. Penguin Press, March 2008

Exhibitions

Richard Meier (Richard Meier & Partners Architects): "Art and Architecture" at the Louise T Blouin Institute, London.

We invite all Fellows and Foreign Honorary Members to send notices about their recent and forthcoming publications, scientific findings, exhibitions and performances, and honors and prizes to bulletin@amacad.org. ■

From the Archives

Lyman Spalding (1775 – 1821), a physician who practiced in Portsmouth, New Hampshire, compiled and distributed annual "Bills of Mortality" giving the causes of death, during the years 1800 – 1813, of residents of Portsmouth.

"To promote and encourage medical discoveries" was one of the specific purposes of the Academy, as stated in the 1780 Charter. One year later the founders set up a class of members to "examine the various diseases of the Country, that are most prevalent, the causes of disorders peculiar to the country, the longevity of the inhabitants, the ratio between births and deaths. . . . " The Academy's archives contain manuscript and printed reports solicited for discussion at Stated Meetings and for possible publication in the *Memoirs*.

Bill of Mortality for Portsmouth, New Hampshire, 1808
Donated to the Academy by the compiler, Dr. Lyman Spalding

BILL OF MORTALITY,

For Portsmouth, Newhampshire, for A. D. 1808.

BY LYMAN SPALDING, M. D.

COMPLAINT.	AGE.	MALES.	FEMALES.	JANUARY.	FEBRUARY.	MARCH.	APRIL	MAY.	JUNE.	JULY.	AUGUST.	SEPTEMBER.	OCTOBER.	NOVEMBER.	DECEMBER.	TOTAL.
Abscess	14 years	1												1		1
Angina Pectoris	63 years	1												1		1
Aphtha	3w, 1, 7m, 2 weeks	2	2							1	1	1	1			4
Apoplexy	48 years		1						1							1
Atrophy	1w, 60y, 59y, 6m, 60, 1, 1, 66 years	6	2				2		2		2	1		1		8
Bleeding at the stomach	48 years	1							1							1
Cholera of Infants	2, 1, 2 years	2	1									2		1		3
Consumption	41 68 34 55 66 44 32 68 9 15 51 61 30 51 68 31 8 19 21 51 years	8	12	1	3	1	3	2	2	1	2	1		4		20
Convulsions	2, 2, 1w, 1m, 2, 1, 3w, 1, 40y, 3w, 65y 1w	5	7		3			3	2		2	2				12
Croup	2 years	1													1	1
Dropsy	26, 46, 43, 58 years	2	2								1	1		2		4
Dropsy in the brain	9m, 1, 2, 9 years		4						1	1				2		4
Dysentery	1, 1 year		2								2					2
Erythema	6m, 1 week		2											2		2
Fever billious	6m, 76, 29 years	3					1				1			1		3
Fever puerperal	24 years		1										1			1
Fever pulmonic	80, 68, 37, 35, 4 years	4	1				2	2	1							5
Fever typhus	19 years	1											1			1
Hooping Cough	1y, 2, 9, 2, 3 months	3	2	1						1				3		5
Intoxication	35 years	1											1			1
Malignant sore throat	2 years		1								1					1
Mortification	51, 8, 37 years		3	1						1				1		3
Nephritis	34 years		1		1											1
Nonclosure of the foramen ovale and canalis arteriosus	2 weeks	1								1						1
Old age	80, 90, 80, 79, 87, 82, 75 years	3	4	1			2	2				1	1			7
Palsy	75 years		1												1	1
Phrenitis	63 years	1						1								1
Schirrous bladder	74 years	1													1	1
Schirrous liver	60, 40 years	1	1					1						1		2
Sudden	53y, 2d, 77 years	2	1	1	1								1			3
Worms	2 years	1													1	1
CASUALTIES: Burnt	5 years	1											1			1
CASUALTIES: Drowned	20, 49, 5, 18 years	4		1				1		1				1		4
CASUALTIES: Suicide	35 years	1					1									1
BIRTHS Males 141, Females 134 } 275 still born 8																
MARRIAGES 56	Total	57	51	6	8	1	11	12	10	7	12	9	7	21	4	108

PORTSMOUTH, the capital of the state of Newhampshire, situated 43° 5′ north latitude, and 6° 26′ east longitude from Washington, contains about 7000 inhabitants.

The Annual Fund is Critical to Academy Projects and Studies: Fiscal Year Closes March 31

The Academy's 2007 – 2008 Annual Fund is nearing its closing date of March 31. With the help of generous Fellows and friends, Development Committee Cochairs Louis Cabot and Robert Alberty hope to surpass the $1.5 million mark set last year.

If you have already made a gift to the Annual Fund, thank you. If not, we urge you to participate by March 31. The Annual Fund helps to support Academy projects and studies, publications and outreach, website, meetings, and other activities for Fellows across the country. Every gift counts toward reaching our ambitious goal.

For assistance in making a gift to the Academy, please contact the Development Office (email: dev@amacad.org; telephone: 617-576-5057). ■

AMERICAN ACADEMY
OF ARTS & SCIENCES

Norton's Woods, 136 Irving Street, Cambridge, MA 02138
telephone 617-576-5000, *facsimile* 617-576-5050,
email aaas@amacad.org, *website* www.amacad.org

Bulletin Winter 2008
Issued as Volume LXI, Number 2

The Bulletin of the American Academy of Arts & Sciences (ISSN 0002 – 712X) is published quarterly by the American Academy of Arts & Sciences. Periodicals rate postage paid at Boston, MA, and at additional mailing offices. Postmaster: Send address changes to *Bulletin*, American Academy of Arts & Sciences, 136 Irving Street, Cambridge, MA 02138.

PHOTO CREDITS

Steve Rosenthal	inside front cover
Martha Stewart	pages 1; 3, bottom; 4 – 10; 12 – 15; 24; 26; 29; 32; 36; 39; 41; 62 – 75; 77 – 79
Rod Searcey	pages 42 – 46; 52
Jim Block	pages 54, 61

AMERICAN ACADEMY
OF ARTS & SCIENCES

AMERICAN ACADEMY OF ARTS & SCIENCES
Norton's Woods
136 Irving Street
Cambridge, MA 02138-1996 USA

telephone 617-576-5000
facsimile 617-576-5050
email aaas@amacad.org
website www.amacad.org