AMERICAN ACADEMY OF ARTS & SCIENCES

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Contents

AMERICAN ACADEMY
OF ARTS & SCIENCES

Calendar of Events

Saturday, October 11, 2008

Stated Meeting and Induction Ceremony – Cambridge

Location: Sanders Theater, Harvard University

Sunday, October 12, 2008

Stated Meeting – Cambridge

Presentation of the Rumford Prize and Symposium on The Nuclear Future

Speakers: George P. Shultz (Stanford University), **Sam Nunn** (Nuclear Threat Initiative), **Sidney D. Drell** (Stanford University), **Steven E. Miller** (Harvard University), **Scott D. Sagan** (Stanford University), **Robert Rosner** (Argonne National Laboratory; University of Chicago), **William J. Perry*** (Stanford University), and **Richard K. Lester*** (Massachusetts Institute of Technology)

Location: House of the Academy

Friday, October 24, 2008

Stated Meeting – Cambridge

Andrei Sakharov: The Nuclear Legacy

Speakers: Paul Doty (Harvard University), **Matthew Bunn** (Harvard University), **František Janouch** (Royal Institute of Technology, Stockholm), **William Miller** (Woodrow Wilson International Center), and **Pavel Podvig** (Stanford University)

Location: House of the Academy

Thursday, November 6, 2008

Stated Meeting – New York

Judicial Independence

Speakers: Sandra Day O'Connor (Supreme Court of the United States), **Judith Resnik** (Yale Law School), **Viet Dinh** (Georgetown University Law Center), **Bert Brandenburg** (Justice at Stake), and **Linda Greenhouse** (*The New York Times*)

Location: New York University School of Law

**to be confirmed*

Saturday, November 8, 2008

Stated Meeting – Chicago

The Invisible Constitution and the Rule of Law

Speakers: Diane P. Wood (U.S. Court of Appeals, Seventh Circuit), **Frank H. Easterbrook** (U.S. Court of Appeals, Seventh Circuit), **Geoffrey Stone** (University of Chicago Law School), and **Laurence Tribe** (Harvard Law School)

Location: Northwestern University School of Law

Wednesday, November 12, 2008

Stated Meeting – Cambridge

Living and Dying: James Merrill's Last Poems

Speaker: Helen Vendler (Harvard University)

Location: House of the Academy

Monday, December 1, 2008

Stated Meeting – California

Reflecting on the Election and its Consequences

Speakers: John Hennessy (Stanford University), **David Brady** (Stanford University), and **Pamela Karlan** (Stanford University)

Location: Stanford University

Tuesday, December 2, 2008

Stated Meeting – California

Challenges to Public Universities

Speakers: Robert Birgeneau (University of California, Berkeley) and **Mark Yudof** (University of California)

Location: University of California, Berkeley

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

Reexamining U.S.-Russia Relations

Robert Legvold

The Academy is conducting a major reexamination of U.S. foreign policy toward Russia. The goal of the new study is to develop a comprehensive, coherent, and effective policy on U.S.-Russian relations for consideration by a new U.S. administration, the incoming Congress, and important segments of the media.

"Since the fall of the Berlin Wall nearly 20 years ago, U.S. policy toward Russia and its neighbors has become fragmented, inconsistent, and fleeting. Yet, Russia and other former Soviet states are increasingly important in the international arena, particularly with respect to energy security, nuclear nonproliferation, illicit trade, and terrorism," said Academy Fellow and project leader Robert Legvold, the Marshall Shulman Professor Emeritus of Political Science at Columbia University.

"The upcoming American presidential election provides an opportunity to rethink U.S.-Russian relations," Legvold added. "This project offers national leadership a broad analytical strategy and concrete recommendations for an American policy toward Russia that could enhance the security and national interests of both countries."

The study is convening a diverse group of policymakers, business leaders, policy analysts, and academics to participate in the initiative. It will develop a scholarly reassessment of U.S. policy toward Russia; a new coalition of analysts drawn widely from the academic and public policy communities; reports and white papers with recommendations to various constituencies; and outreach efforts to promote the findings within the executive and legislative branches of government, the media, and the policy community. These efforts have already led to several productive meetings with leading figures in both Russia and the U.S. governments.

This project offers national leadership a broad analytical strategy and concrete recommendations for an American policy toward Russia that could enhance the security and national interests of both countries.

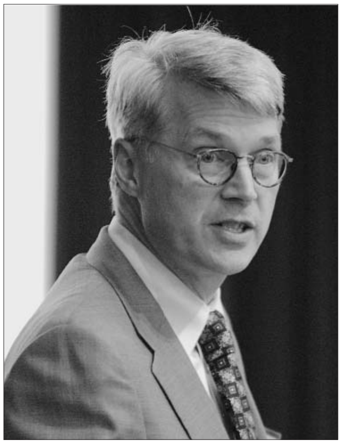
The Academy is collaborating on the project with Georgetown University, the National Defense University's Institute for National Security Studies, the Carnegie Moscow Center, and the Center for Strategic and International Studies, among other organizations. At the Carnegie Moscow Center, Rose Gottemoeller, the Center Director, is leading a 12-part seminar series on the security dimension in U.S.-Russian relations, with primary emphasis on areas of real and potential nuclear cooperation. Angela Stent of Georgetown University and Eugene Rumer of the Institute for National Security Studies are leading a series of meetings devoted to the larger questions surrounding the relationship and the challenges facing U.S. policy. Recent meetings have focused on developing a framework for assessing key political and economic trends in Russia and values versus interests when dealing with Russia. Ambassador James F. Collins, now at the Carnegie Endowment for International Peace, is coordinating conversations with former ambassadors regarding the issue of structure in the U.S.-Russia relationship. And Andrew Kuchins, Director of the Russia and Eurasia Program at the Center for Strategic and International Studies, will head up a study group to consider the increasingly complex and important economic dimension of U.S.-Russian relations.

The project Steering Committee, which had its first formal session in July 2008, includes Robert Legvold (Columbia University), Deana Arsenian (Carnegie Corporation of New York), Coit Denis Blacker (Stanford University), James F. Collins (Carnegie Endowment for International Peace), Rose Gottemoeller (Carnegie Moscow Center), Thomas E. Graham (Kissinger Associates), Thomas R. Pickering (Hills & Company/The Boeing Company), Eugene Rumer (Institute for National Security Studies), Strobe Talbott (The Brookings Institution), and Angela Stent (Georgetown University).

As Academy Chief Executive Officer Leslie Berlowitz noted, the Academy has long conducted cutting-edge research on international security issues, beginning with seminal work on arms control in the 1960s. Recently the Academy concluded a study, also led by Legvold, that produced a series of four books examining security challenges in the new nation-states formed after the dissolution of the Soviet Union. Other security projects currently underway at the Academy include Reconsidering the Rules of Space, led by John Steinbruner (University of Maryland) and Neal Lane (Rice University); The Global Nuclear Future, led by Steven E. Miller (Harvard University) and Scott Sagan (Stanford University); and Countering Corruption in Nation-States, led by Robert I. Rotberg (Harvard University).

For more information about the project on U.S. Policy Toward Russia, please visit the Academy's website: http://www.amacad.org/projects/russia.aspx.

New Study on the Global Nuclear Future



Scott Sagan (Stanford University), project director

Steven E. Miller (Harvard University), project director

Rising energy needs as well as concerns about climate change resulting from fossil fuel use have led to a new interest in civilian nuclear technology. However, a rapid increase in the use of nuclear energy could affect global security as more states acquire nuclear expertise and nuclear materials. The expansion of nuclear power plants and related facilities worldwide can potentially provide terrorist groups with an attractive new set of targets for sabotage or theft.

The Global Nuclear Future Initiative will generate a set of policy recommendations for balancing the global demand for nuclear power with the need to contain proliferation and promote nuclear safety. It consists of several interrelated studies that will devise mechanisms for the physical security of nuclear facilities and materials, create strategies for the management of the fuel cycle, propose reforms to the nonproliferation treaty regime, and generate concrete policy options for decision-makers in Washington and in foreign capitals for managing the security consequences of the expected global expansion of nuclear energy.

Ariel Levite (Carnegie Endowment for International Peace) and Albert Carnesale (University of California, Los Angeles) at the Global Nuclear Future workshop.

The Academy is in a unique position to address this critical challenge. Taking advantage of its convening power and its Fellows' wide-ranging expertise, the Academy is bringing together constituencies who typically do not communicate with one another: nuclear engineers and policy-makers, nuclear industry leaders and environmentalists, social scientists and representatives from the national laboratories. Because many of the crucial decisions that will shape the nuclear future will be made in collaboration with other nations, experts from overseas, including representatives from foreign governments and international organizations, will participate in the Academy's studies.

Steven Miller (Harvard University) and Scott Sagan (Stanford University) are codirecting the Initiative, and Thomas Isaacs (on leave from Lawrence Livermore National Laboratory) is the Research Coordinator. In May 2008, the Academy, in collaboration with the Carnegie Endowment for International Peace, hosted a workshop that focused on international cooperation and best practices; identified areas of agreement and disagreement among the participants, including industry leaders, policy-makers, scientists, and scholars; and developed a research agenda.

Renewed interest in nuclear power comes at a time when the nuclear order based on the 1968 Nuclear Nonproliferation Treaty (NPT) faces serious challenges. Research under the Global Nuclear Future Initiative will address the question of reforms of the international nonproliferation regime. It will culminate in a briefing paper summarizing the main policy recommendations generated by the project, with the goal of influencing the policy positions of both the United States and other members of the international community prior to the crucial NPT Review Conference in 2010.

More information about the Initiative is available on the Academy's website at http://www.amacad.org/projects/globalNuclear.aspx.

John F. Ahearne (Sigma Xi Center) and Robert Rosner (Argonne National Laboratory) at the May workshop.

Global Nuclear Future Initiative · May 2008 Workshop

Thomas Cochran (National Resources Defense Council) and Carl Kaysen (Massachusetts Institute of Technology)

Corey Hinderstein (Nuclear Threat Initiative) and Charles McCombie (Association for Regional and International Underground Storage)

Alan Hanson (AREVA) and Alan Fiorente (Bechtel Nuclear Power)

Raymond Juzaitis (Texas A&M University) and Patricia Falcone (Sandia National Laboratories)

Zhou Dadi (Energy Research Institute of the National Development and Reform Commission, Beijing) and Matthew Bunn (Harvard University)

Countering Corruption

Robert Rotberg (World Peace Foundation; Harvard University)

The nature of corruption is changing. Today it is intimately connected with processes of globalization; its impact is large, and the problem is not being adequately addressed with existent strategies. This new Academy project will be conducted in collaboration with The World Peace Foundation (WPF) and the Program on Intrastate Conflict at the Kennedy School, Harvard University.

Under the leadership of Academy Fellow Robert Rotberg, President of the WPF, an international group of scholars will address the problem of corruption and expand the lens through which it is viewed. Each member of the group will contribute an essay to an edited volume.

Peter Eigen (Transparency International) and Erica Chenoweth (Harvard University)

Tentatively titled *Corruption and World Order*, the volume will explore the changing nature and character of corruption, bringing new issues, such as human rights and the relationship between corruption and health and education, into the discussion. Case studies will be presented in a number of the essays, elucidating the issue of corruption in a variety of settings, including Papua New Guinea, Nigeria, Kosovo, and Mozambique. More broadly, the volume will include studies on measuring corruption and an exploration of the links between corruption and terrorism and corruption and nuclear weapons.

Contributors to the volume are Matthew Bunn (Kennedy School, Harvard University), Erica Chenoweth (Kennedy School, Harvard University), Sarah Dix (National Research Institute, Papua New Guinea), Peter Eigen (Transparency International), Kelly Greenhill (Tufts University), Charles Griffin (Brookings Institution), Benjamin Heineman (Kennedy School, Harvard University), Jomo K. S. (United Nations), Lucy Koechlin (Basel Institute on Governance), Johann Graf Lambsdorff (University of Passau and Transparency International), Robert Legvold (Columbia University), Susan Rose-Ackerman (Yale University), Daniel Jordan Smith (Brown University), Rotimi T. Suberu (University of Ibadan, Nigeria), and Jessica Christine Teets (University of Colorado, Boulder).

Carl Kaysen (Massachusetts Institute of Technology) is serving as Project Advisor.

Please visit the Academy's website at http://www.amacad.org/projects/corruption.aspx for more information about this project.

John Heilbrunn (Colorado School of Mines)

Jessica Christine Teets (University of Colorado, Boulder) and Charles Griffin (Brookings Institution)

Susan Rose-Ackerman (Yale University)

Academy Meetings

An aerial view of Macau, China. Image © Richard Baker/Corbis.

Sustainable Cities

Joel E. Cohen, Daniel L. Doctoroff, and Martin Filler

Welcome by Frank A. Bennack, Jr.

This presentation was given at the 1921st Stated Meeting, held at the Hearst Tower in New York City on December 3, 2007.

Frank A. Bennack, Jr.

Frank A. Bennack, Jr. is Vice Chairman of the Board, Chairman of the Executive Committee, and immediate past President and Chief Executive Officer of Hearst Corporation. He has been a Fellow of the American Academy of Arts and Sciences since 2007.

Welcome

Let me warmly welcome all of you. I am privileged to be a new inductee into the Academy, but tonight I am representing the Hearst Corporation and this facility. Besides its beauty and the fact that it is the first LEED Gold Medal building in New York City, this structure has an interesting story behind it. In 2001, as Chief Executive Officer of the Hearst Corporation, I scheduled a board meeting for September 12 to consider the Norman Foster design and to get the go-ahead to begin construction of a high-rise building in New York.

Needless to say, that meeting did not take place: our out-of-state directors were unable to get to New York. But more importantly, it was impossible to find anyone interested in building a high-rise building in New York on September 12, 2001. However, by the end of October, our board of directors had the courage to say we are staying in New York, and we are building this building.

So began the process of transforming a landmark William Randolph Hearst building. The architect for Mr. Hearst was Joseph Urban; thus we call this theater the Urban Theater. Joseph Urban had been the graphic eyes and ears of Hearst in the movies, and he was more a set designer than he was an architect. But he designed this six-story building with its eight allegorical statues representing comedy, tragedy, music, art, industry, sport, the sciences, and printing. Hearst believed that this neighborhood was going to become the theatrical, literary, and media center of New York, which it is in many respects becoming now, with Time-Warner and a number of other groups in this area.

In any event, we hired Norman Foster, and as they say, the rest is history. This is the first building in New York City to be awarded the LEED Gold Medal; LEED stands for "leadership in energy and environmental design." Many others will follow us, but we feel privileged to have set the pace. There are many reasons why this building received this high ranking: We saved 2,000 tons of steel, which means we used 20 percent less steel in construction than we would have normally. Moreover, 90 percent of the structural steel is recycled. We also use 26 percent less energy, which translates into reducing as much carbon dioxide in a year as could be achieved by taking 174 cars off the street. Additionally, we collect rainwater on the roof, which besides serving us inside the building keeps that rainwater from flooding into the city's sewers during heavy rainfalls. Finally, we installed light sensors around the building that turn lights on and off as people enter and exit rooms. So all over the building, we are controlling the output of electricity, which is directly related to how much natural light is coming in as well.

We are proud of this building. We always wanted to do something that was great for the city of New York and for our employees. But we have to give Norman Foster an enormous amount of credit for leading us in the direction of being as green as we are.

Joel E. Cohen

Joel E. Cohen is the Abby Rockefeller Mauzé Professor of Populations at Rockefeller University and Columbia University. He has been a Fellow of the American Academy of Arts and Sciences since 1989.

Presentation

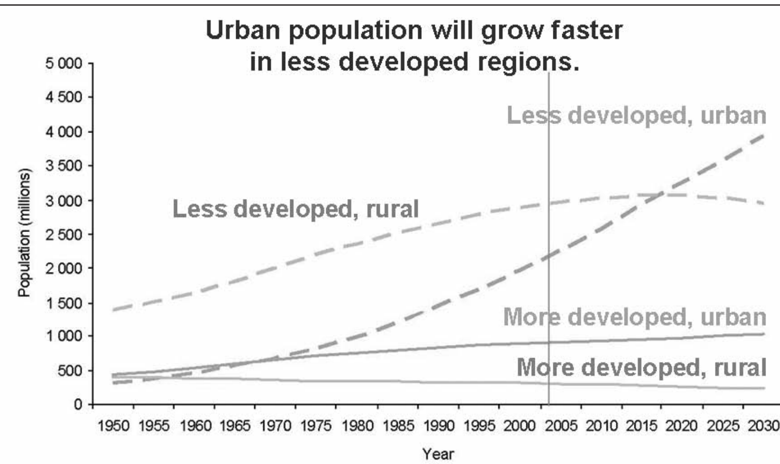
I am going to take a global perspective on cities in the next half century. Though the demographic statistics are imprecise, sometime in 2007 or 2008 the world will, for the first time, have more urban than rural people. By 2050, the world's urban population will probably double. If that happens, it will be necessary to build, in the next 40 to 45 years, urban infrastructure for as many additional people as the people now in cities.

The rural population of today's so-called more developed countries has been declining since the beginning of the twentieth century, while the urban population of these countries has been increasing slowly (see Figure 1). The

Cities will face four main challenges over the next half century: urban population growth in developing countries, population aging, environmental changes, and governance.

population of today's less developed countries has been predominantly rural; the rural population rose steeply but is now leveling off. Lately, the urban population in the less developed countries has been rising extremely rapidly and will overtake the rural population in the less developed countries within fifteen years. Rural populations will be declining everywhere before the middle of this century.

Cities will face four main challenges over the next half century. Urban population growth in developing countries is the first challenge. Urban populations grow in three ways: by people migrating from the countryside into cities; by rural areas growing into urban areas; and by births outnumbering deaths in existing urban areas – natural increase, in other words. Migration accounts for about 40 percent of urban population growth, and natural increase for about 60 percent. Until 1800, cities had higher death rates than birth rates. That has changed now; cities are a source of their own growth.



Source of data: UN Population Division, *World Urbanization Prospects* 2003
Source of chart: Joel E. Cohen

Figure 1

The second challenge cities face is aging, especially in developing countries, where rapid aging will interact with rapid population growth.

The third major concern is environmental changes, including climate change; vulnerability to infectious diseases; and limitations in resources like water, energy, and food.

A fourth challenge is governance. When a city outgrows its official political boundary, its government loses the capacity to solve the problems its people face, because governance is shared with surrounding entities. New York City has partially solved this problem by incorporating the five boroughs and by creating institutions of shared governance with neighboring states; a hierarchy of collaboration is necessary, from local community boards through state, regional, national, and international relations. Thus boundary overflow is one major challenge to governance. Another governance issue is congestion. A third is security in two senses: internal security to assure public order and protect the rights of minorities within a city, and external security to protect a city against its enemies. Employment to assure that people have the means to live in the city is a fourth issue. Fifth, and foundational for me, is inequity – ensuring that there are not such raw gaps between the rich and the poor that the city becomes unstable.

Virtually all of the increase in the world's population is going to happen in cities in presently poor or middle-income countries.

In my limited time here, I am going to talk only about the first two of these challenges: rapid urban population growth in developing countries and population aging (the increase in the *proportion* of elderly people in the population). The challenges of the environment and governance are equally important topics for another conversation.

The urban population of the world will grow roughly twenty-two-fold from 1900 to 2030. In 1900, 210 million people lived in cities (about two-thirds of the current U.S. population). According to the UN Population Division's *World Population Prospects*, just under 5 billion people will live in urban areas in 2030. Over the next few decades, the urban areas of less developed regions are projected to absorb nearly all the population growth expected worldwide. Virtually all of the increase in the world's population is going to happen in cities in presently poor or middle-income countries.

This projected increase depends on assumptions about the future. Which future we get depends on which assumptions turn out right. The world's population is now about 6.7 billion. If fertility rates continue as they are today, global population will grow to almost 12 billion by 2050. But the UN Population Division anticipates that the average number of children born per woman in a lifetime will continue to fall approximately as it has over the last half century. If so, the global population of 2050 is projected at 9.1 billion (in the so-called "medium" projection). If the average woman has half a child more than anticipated in the medium projection, then the population will grow to 10.6 billion by 2050 (in the so-called "high" projection). If the average woman has half a child less than anticipated in the medium projection, then the population will grow to 7.7 billion by 2050 (in the so-called "low" projection). A difference, on average, of one child per woman per lifetime from now to 2050 entails a difference in 2050's world population of 2.9 billion people – the difference between 10.6 billion people and 7.7 billion people.

The future is very sensitive to what we do starting now – and in particular to how much we invest in the education and health of children worldwide, especially girls, especially the poor.

By 2050 there will be three would-be grandparents for every young child.

The future is very sensitive to what we do starting now – and in particular to how much we invest in the education and health of children worldwide, especially girls, especially the poor. In general, people who are educated take greater interest in the quality than in the quantity of their children.

Are the added billions of people going to live in big cities or in villages? About half of the world's people live in cities of 500,000 or fewer. Mid-sized cities, with populations of half a million to a million, have been the central trend for the last 25 years, and we expect that to remain the case in the future.

Between 1900 and 1950, the world added a million urban people every 35 days. Between 1950 and 1980, a million urban people were added every 12 days. Between 1975 and 2000, every seven days. Between 2000 and 2005, every six days. From now to 2030, the world will need to accommodate another million urban people in poor and middle-income countries every five days. That is a great challenge.

Where are those new city folks going to live? China is the country with the largest population now, but not for long. India's population will overtake China's within the next couple of decades. Soon after that, Africa's people will outnumber both India's and China's. While Africa and Asia are the least urbanized areas in the world today, by 2030, Asia and Africa will rank first and second in the number of urban dwellers. By 2030, almost seven of every ten urban residents in the world will live in Africa or Asia.

The difficulties inherent in this colossal transformation are obvious, but it could have a bright side. Cities reduce the economic incentives for families to have many children. And it is easier to reach children with education in cities than in the countryside.

The second challenge I mentioned above is aging. From now on, the world will have fewer young people (up to age 4 years) than old people (aged 60 plus). By 2050 there will be three would-be grandparents for every young child. Globally, between now and 2050, the number of people aged 80 and older will increase by a factor of 4.5, while the number of people aged 60 and older will increase by a factor of 3. If the total population grows by a factor less than 1.4 between now and 2050, as the medium projection expects, the proportion of elderly people will

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rise dramatically. Because developing countries are starting with fewer elderly people now, their numbers of old people will increase even faster than the global average, by factors of 6 for those 80 plus and 4 for those 50 plus. The biggest increases in aging will be in the places least equipped to deal with it, namely, the developing world.

While the relative increase of elderly is most rapid in some developing countries, the greatest numbers of elderly are presently in more developed countries. Cities in developing countries will face an unprecedented confluence of rapid population growth and rapid aging. Will the world's cities be ready? How will whatever is in scarce supply be allocated between tomorrow's children and tomorrow's elderly?

Daniel L. Doctoroff

Daniel L. Doctoroff was Deputy Mayor for Economic Development and Rebuilding for the City of New York. He is currently President of Bloomberg L.P.

Presentation

I would like to talk about how one city, namely your city, becomes a sustainable city. Let me begin by saying that "sustainability" is rapidly becoming one of the most overused terms in the English language. That's not to say it doesn't have enormous value. However, because there are so many different definitions I thought I'd start off by giving you the definition that the mayor and I used when creating PlaNYC. To us, sustainability is an almost sacred obligation, to leave this city better off for future generations than we who are here today found it.

We believe New York can be a sustainable city, and we have proposed a series of steps to reach that goal. The largest barrier is not the development of technologies or strategies. No, the biggest obstacle is will and leadership. By definition, when you think about sustainability as we've defined it, it means taking actions today – some of which have significant costs – that will better future generations. These are long-term investments. Those are not things that, by their very nature, our political system is well equipped to make.

Two years ago, we set out to think about how to make New York a sustainable city. The process involved literally thousands of New Yorkers. We gathered experts for our sustainability advisory board, at least one of whom, Andy Darrell from Environmental Defense, is here today. We reached out to the public

Sustainability is an almost sacred obligation, to leave a city better off for future generations than we who are here today found it.

and asked them what they saw as the challenges to the future of New York City. Our website received thousands and thousands of comments. We went out to town halls in every borough. And after a lot of research, we discovered three fundamental challenges to making New York a sustainable city.

The first ties into what Joel Cohen said: this city is going to grow. Our estimate is that the population of this city will grow from 8.2 million people today, an all-time high, to 9.1 million people by 2030. Think about how crowded the city is today, and then add almost a million more people into our very small five boroughs.

The second major challenge is our infrastructure. By 2030, our water system, our energy network, our roads, our bridges, our subways, our commuter rail lines will all be at least 100 years old. Every day, we see evidence of increasing failures as a result of underinvestment in infrastructure over the past several decades. When you take growth and aging infrastructure into account, and mix that with an already precarious environment, the third challenge is simply that the worsening of our insecure environment is becoming even more problematic. And so, the three challenges – growth, infrastructure, and the environment – are what we have to think about as we design a plan for a sustainable city in the future.

In doing so, we learned three fundamental things. The first is that these three challenges and the solutions required to deal with them are completely interdependent. You cannot think about land use without thinking about how you move people around, i.e., transportation. Your transportation network is highly dependent upon energy. Energy produces air quality problems. And, ultimately, every element of our urban environment affects perhaps the greatest challenge we as a world face today, which is climate change.

A more encouraging note, however, is that there does not have to be a conflict between creating a city that is sustainable *and* capable of economic growth – they can in fact be mutually reinforcing. Reducing traffic congestion, expanding our mass transit system, upgrading the energy grid and providing more capacity, and cleaning up contaminated land can remove many of the greatest barriers to economic growth. This was perhaps the single most important discovery we made: that smart investments in sustainability more than pay for themselves economically.

The third thing we found was that we didn't have to invent it all ourselves. As we developed PlaNYC, we shamelessly stole from cities around the world: congestion pricing from London and Singapore; renewable energy from Berlin; new transit policies from Hong Kong; pedestrianization and increased use of cycling from Copenhagen; bus rapid transit from Bogotá, Colombia; and even water-cleaning mollusks from Stockholm.

When you think about sustainability as we've defined it, it means taking actions today – some of which have significant costs – that will better future generations.

The result of all of this is PlaNYC, the long-term plan that the mayor unveiled last April. It is the most comprehensive plan ever undertaken by a city to address its own urban environment. It includes 127 separate initiatives, each one of them detailed, each one of them with identified financing sources. Together, these initiatives will enable us to achieve greater, more efficient use of our land, solving the problem of how the 2.7 million New Yorkers who don't live within walking distance of a park can live within walking distance. The plan details how we will clean up all 7,600 acres of our brownfields, how we can reduce travel times while accommodating all the additional people, and it goes on and on. It includes specific actions that will create a sustainable city. You've heard about some of them, such as congestion pricing. Planting a million trees. Hybrid taxis. Greening the building code. Each one, as I mentioned, has a detailed implementation plan.

Our estimate is that the population of New York City will grow from 8.2 million people today, an all-time high, to 9.1 million people by 2030.

Now let's return to the initial topic of political will: the mayor is only going to be in office for another 760 days. How do we sustain a sustainability plan that is designed to be achieved over a 20-year period? That, we believe, is where you come in. We need you to place pressure on our successors to sustain this. Already, we're placing pressure on ourselves by reporting our progress on the 127 initiatives every six months. Ultimately, however, we're not going to be here after 760 days, and so it will be up to people like you, who have influence, to hold our successors accountable.

Martin Filler

Martin Filler is a longtime contributor to The New York Review of Books *and former architecture critic of* House & Garden. *He has been a Fellow of the American Academy of Arts and Sciences since 2003.*

Presentation

What interests me as a critic trained as an architectural historian is the prehistory of the green cities movement. It takes us back to the mid-nineteenth century, to the English garden city movement. There was this sense in England that these Dickensian overgrown cities of the Victorian period (especially London, which in the nineteenth century was larger by far than any other city in the world) had reached the absolute limits of expansion. A number of theorists in mid-nineteenth-century England, Sir Ebenezer Howard chief among them, developed the notions of green belts and the maximum desirable size of cities, thoughts which were actuated in the early twentieth century with such new developments as Letchworth Garden City and Welwyn Garden City in England.

The English movement influenced a number of American thinkers – most notably Lewis Mumford and the other members of the Regional Planning Association of America (RPAA), a group of reformists in the early decades of the twentieth century – to institute some of these notions of limits on growth and sustainable cities for a new world and certainly for a new economic development in the United States. It was taken almost as an article of faith among RPAA members that the ideal size for a city was somewhere between 100,000 and 500,000, and that it was much better to build numerous small cities of that size in a constellation around existing cities, insulated with green belts. We see this type of development in areas around London particularly, but also in other areas in Europe, specifically in the cities that were rebuilt after the war. So it's quite interesting in retrospect to see how in recent years notions of appropriate city size have changed.

New York is now sixth on national lists of green cities – or sustainable cities, if you will. In fact, according to the most recent calculation – which is based upon a complicated formula that involves various factors, including public transit, renewable energy, availability of local food, development and growth policy, and congestion and traffic patterns – Portland is the greenest city in the United States, followed by San Francisco and then Seattle – three choices that would probably not surprise many of us. Chicago follows in fourth place, Oakland in fifth, and New York in sixth. Some of you may be puzzled by New York's relatively high ranking, but New York is actually remarkably carbon efficient thanks to its density, availability of rapid and mass transit systems, and proximity to locally grown food, among other things.

What interests me as a critic trained as an architectural historian is the prehistory of the green cities movement.

This city is starting from a position of strength, but undoubtedly the initiatives undertaken by the Bloomberg administration have done a great deal to increase its strength. Among the factors that Deputy Mayor Doctoroff cited – growth, infrastructure, and environment – the notion of growth has to be looked at most closely. Of course we want economic growth. Unless the city can employ people and maintain a viable local economy, the rest of these issues are moot. But I'd like to see perhaps more advocacy in places that would serve to galvanize the public interest. I was somewhat disappointed by the recently released proposals for the Hudson Yards development, which I was hoping would be a showcase for sustainable design. I did not see a strong expression of that, and I hope that as those projects are refined and refocused, there would be more emphasis on sustainability.

I can't stress infrastructure strongly enough. There's no question, as the Deputy Mayor has just pointed out, that 100-year-old systems of every sort – mass transit, water, all kinds of things that we depend on in this city – are reaching crisis proportions. This is due in part to the fact that the city has not received the funding that it should have received for several decades, at least since the 1960s, an issue that has very much to do with inequities in terms of returning taxes to this city, and one that the Bloomberg administration is well aware of. More help from the national government could improve things tremendously. The enormity of the infrastructure problem was brought home with great force last summer when the city was practically brought to its knees by nothing more than a heavy rainstorm, revealing how climate change, rising sea levels, and other issues are certain to become more menacing in the decades ahead.

Luckily, a number of institutions are looking seriously at these problems; they include the Institute for Sustainable Cities at Hunter College of the City University of New York. The Institute has an excellent website, which I would urge you all to visit. The Sustainable Cities Program of the University of Northumbria in the United Kingdom also addresses many of the same issues.

A few weeks ago, I had the pleasure of serving on an urban redevelopment jury for a large commercial multiuse scheme in Istanbul that was sponsored by the Zorlu Group, a Turkish real estate developer who is trying to approach sustainability with the same kind of seriousness and attitude toward excellence as the Hearst Corporation did in hiring Norman Foster to design this remarkable building. The jury included the Japanese architect and Pritzker Prize winner Fumihiko Maki and others, and the participants included a number of international stars. We found attentiveness to environmental issues shockingly superficial. The designs included, for example, trees positioned in balconies and other superficial gestures to green architecture that were handled like parsley on a plate.

It was taken almost as an article of faith that the ideal size for a city was somewhere between 100,000 and 500,000, and that it was much better to build numerous small cities of that size in a constellation around existing cities, insulated with green belts.

One of the participants said, "Thank you, no, I don't think I want salad with my architecture." The Hearst building, on the other hand, is an encouraging sign of the ways in which large corporations will engage these issues with the high level of expertise that has always been typical of the Foster office. Regardless of what one may think of it in terms of design, in terms of function and in its address of environmental issues, it's unimpeachable.

As much as I applaud the initiatives in this city that can serve as a real model for other cities in this country and around the world, I would love to see a few more dramatic set pieces that can further engage the public in the same way as the redevelopment of Ground Zero engaged the public in notions of urban planning. The enormous public response to that program gave a good sense of how the public can be engaged if approached in the proper way. ■

The Art and Science of Conservation

Robert Campbell, Jorge Silvetti, and Jerry Podany

Welcome by James Wood

This panel discussion was given at the 1924th Stated Meeting, held at the Getty Villa in Malibu, California, on February 23, 2008.

Inner Peristyle at the J. Paul Getty Museum at the Getty Villa in Malibu. Photo by Julius Shulman and Juergen Nogai. © 2006 J. Paul Getty Trust.

James Wood

James Wood is President and Chief Executive Officer of the J. Paul Getty Trust. He has been a Fellow of the American Academy of Arts and Sciences since 1997.

Welcome

The subject of tonight's discussion at the Getty Villa, the art and science of conservation, is central to our complex identity. We are quite unique in the mix of expertise and viewpoints that resides under several roofs on two campuses, which, in their totality, make up a community that is university and laboratory, art museum and public gardens. Therefore, it is particularly appropriate for us to be hosting the Academy, with its diverse membership and focus on the arts and the sciences.

Of our two campuses – I hope you all have a chance to visit both – it is ideal that we are meeting at the Villa tonight. While a vital part of the J. Paul Getty Museum, it has also evolved into a center for comparative archaeology, with a mission beyond the study of the ancient Mediterranean. In fact, in the years ahead we are planning exhibitions and research programs that will deal with pre-Columbian Mexico and ancient bronzes from Southeast Asia, among several other topics.

The J. Paul Getty Trust is a young institution, emerging from adolescence to young adulthood. And at this crucial juncture we have reviewed and refocused our mission. Central to its new wording is the phrase "To further knowledge and nurture critical seeing." Our means should and must be as broad as the Academy's membership, while our ends need to be tightly focused on enhancing the individual's experience of specific and exemplary examples of the visual arts.

Robert Campbell

Robert Campbell, a Fellow of the American Academy of Arts and Sciences since 1993, is the Pulitzer Prize-winning architecture critic of The Boston Globe *and writes a regular column, "Critique," for the magazine* Architectural Record.

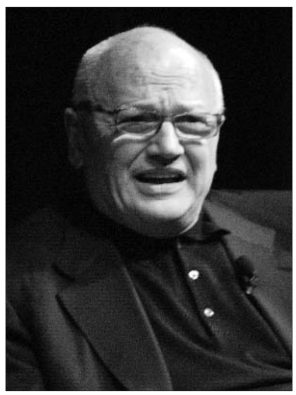
Presentation

My first experience at the Getty Villa was probably 20 or 30 years ago, and although it was certainly elegant, it was also very strange. Back then you drove your car into an enormous hole that seemed to be the basement, and you found your way into a rather dark place with a collection that has changed a great deal since then. I'm glad I had the opportunity to visit so many years ago because it gave me a chance to understand the transformation that has taken place.

That is, for me, a definition of architecture: the art of making places and expressing time.

We will be talking tonight about conservation – conservation of artifacts certainly. But also, for me, a subtler and more interesting kind of conservation: the conservation of an idea of place, a conservation of cultural continuity. This place is quite wonderful, and I hope one of the things we leave with tonight is a realization of why it is so wonderful. It is a place within California. You can see the ocean, the cliffs, the plantings. What was a Villa that was isolated from the rest of the world has now, as it were, been given a place in which to exist. And it's also been given a time, because we can see changes that have taken place on this site over the course of a couple of generations, changes that have taken place in the Getty Villa itself. So it has been linked into a continuum of time that goes back to ancient Romans but comes up to the present. For me, that is a definition of architecture: the art of making places and expressing time.

There is for me, and I think for Jorge Silvetti, a governing metaphor, a fictitious story about this site – often the case with architecture – that gives it meaning. Do you want to try to define that, Jorge?



Jorge Silvetti

Jorge Silvetti is the Nelson Robinson, Jr. Professor of Architecture at the Harvard University Graduate School of Design and a Principal of the architectural firm Machado and Silvetti Associates.

Presentation

I was listening today to some of the docents give tours. They have done a tremendous job at understanding what was here, and what it took to get to where the Villa is now. They tend to start with the same image: the idea of the excavation. To describe the way in which the Villa was reimagined or reconceived is to imagine that it is part of an excavation; that's how you discover. Sure, you enter from above and you see from above. However, what is important for those interested in process is to understand how it came about, how we followed an idea that wasn't our original one. That new idea, like most things in architecture, emerges as you work

We wanted to make this replica of a Roman villa a better tool to understand classical art.

and get hints from solutions or other ideas that are being tested. Our idea also had to take into account what the Getty wanted – not an entirely clear and specific desire – and a few very important functional issues that needed to be solved.

Campbell: Your real idea came by attempting to solve problems then?

Silvetti: Solve problems, yes, including the big, big problem (that now seems to be so simple) of changing the entrance, which is a problem that a lot of museums seem to have had at the end of the twentieth century. In this case, the new design actually corrects the entrance to be authentic to a Roman house. Since its opening in the early 1970s, the Villa was entered at the south end of the outer peristyle from an elevator coming from the garage. Today you enter the museum, the house, from the proper door. This was an interest that the Getty had and something that we approved and adopted as a goal from the very beginning. We wanted to make this replica of a Roman villa a better tool to understand classical art.

The Getty Villa creates a governing story, a metaphor: that this is an archaeological excavation site.

Campbell: The original villa in Herculaneum, on which this was modeled, has never been fully excavated. Scholars have drilled through to it and examined pieces of it to try to find out as much as possible, but nobody knows exactly what it was. The Getty Villa here in California now picks up that history by creating a governing story, a metaphor: that this is an archaeological excavation site; that we cut down and down, and, amazingly enough, we found this temple at the bottom of the excavation. I know that the metaphor did not come at the beginning; it was something that grew out of the process of investigation and design. But it is the reason why you now see horizontal striations in the walls as you approach the Villa, as if archeologists had dug down, level after level, through civilization after civilization. It's why you have what we never had before, the processional entrance, with views down into the fictional excavation site. That entrance pulls the place together in one powerful, artistic idea that doesn't need to be articulated to the visitor: you sense it in any case. How did you arrive at that?

Silvetti: Again, it's the result of attempting to solve problems. We needed to figure out how to bring people to this door because this building is at the bottom of a canyon. In its original state, and with the new large program incorporating many new functional components on the site besides the Museum that emerged after the programming phase,

We are very interested in materials and materiality, and in the quality of the materiality – the sensory aspects of architecture.

we all realized there was no place to put those new buildings and facilities unless you spread it into 60-some acres. But then you would have to move people, hundreds of people, in this site, which is incredibly difficult, especially given the topography. And we knew there were some things that needed to be located between the two buildings that were going to be preserved. So how could we bring people to that door of the Museum?

There seemed to be no place to do that, so one idea – there were many – was to bring people from above. As that idea began to take form, we questioned whether we should bring people up and then bring them down; that seems counter to the idea of something functional. We realized, though, that we would always have to bring people up: even parking requires using elevators or stairs to come to the level of the Villa. The canyon naturally creates the difference of levels. Once we knew that, no matter what, visitors would always have to climb in an elevator or take stairs, that didn't seem to be a wrong thing.

Then there was testing, risking life and limb in the hills, looking and thinking about height. As we moved around at that higher level, we realized for the first time that the Villa did not appear so imposing from above. And when looking from a distance and from above, we saw partial fragments and vignettes of the building framed by trees and such, that only then threw us back to something we said in passing at the beginning: during the competition we mentioned the idea of an archeological dig. It was, though, more or less a poetic idea about looking at this project at that point.

Campbell: Six architects were invited to compete for the job of redoing the Getty, and each was given a sketchbook and told to take it away for two weeks and bring it back. On the basis of what was in the sketchbook, the architect would be chosen. How did you respond when you saw these blank sketchbook pages?

Silvetti: At that time the Getty did not have a clear program, and the site was so difficult that nobody really knew what could be done. It wasn't really possible to run a traditional competition to choose a design and build that. So we were brought here and briefed for one day, with a second day of visits. At the end of those two days, we were each given one blank sketchbook and told that in two weeks, exactly, it had to be postmarked and sent back with our thoughts; that was all. Nobody really submitted a project in the end, and that was the beauty. We recorded thoughts and vignettes; we pasted together some things we liked. We said, "You know, it would be nice if something like this happens."

Campbell: Like what, for example?

Silvetti: Postcards of things that we collected, cutouts from papers, lots of sketches, and writing. It was, in our case, interesting because we were two architects. There was opportunity for dialogue between my partner Rodolfo Machado and me, in which we asked questions of each other and attempted to answer them and register that.

This went on until one day we realized that we had to put it in an envelope and send it. But since there was nothing that we had to finish, there was no pressure.

Real horizontal strata gave us a vocabulary, which is an essential component in any work of architecture – to know the vocabulary you are using in your building allows you to begin to make decisions that are consistent with each other.

Campbell: Has there ever been an exhibition of the six sketchbooks?

Silvetti: Some of the other sketchbooks are absolutely fantastic. They're very hard to exhibit, though, because they are sketchbooks. They are all here, and they were on exhibit when the Villa opened in 2006, to document the project and the process. But, again, they were opened to just one page, so you could see something, but not the whole content.

Campbell: At the time of submitting the sketchbook, what was your idea about what you might do?

Silvetti: We explored all the things that they posed to us in those two days, in terms of access. We talked about a palette of materials. We are very interested in materials and materiality, and in the quality of the materiality – the sensory aspects of architecture. We did talk about materials at that stage, too, although we thought at that time that it was going to be more of a masonry type of building in the more conventional way, rather than the concrete; the concrete came later.

The concrete is also the result of a very pressing need here in this very difficult site. Everybody knows about the technical issues of building in hillsides in California, but they are exacerbated here because you have the big jewel of the crown at the bottom of a canyon. You can't let these hills fall over the museum.

This project starts with, and is resolved with, retaining walls. That's why the language begins to be horizontal language, because we realized that we were building retaining walls from the garage all the way up to the hill and that they will become a dominant feature of buildings and landscape. That becomes the vocabulary, and then you begin to think about it in aesthetic terms. You begin to think, what is the architectural expression of all these retaining walls, because we knew we were going to have them. The idea of horizontal strata appeared to us because they're not only long but also cover an incredible depth when you look at the difference of level in the whole site, which led us to think about the idea of continuity and how we could weave all of this together.

We fixed on using board-form concrete. For those who know a little bit of the history of architecture, concrete still has an association with Roman architecture. The Romans were the first builders to use concrete in an imaginative way. One thing led to the other, and

Rather than striving for an authenticity that it could never have, we decided that this building needed to create an atmosphere that would evoke and provide a setting for the display, study, and enjoyment of the art of antiquity.

we came up with the banding that is incredibly consistent throughout the project. You almost know at what height you are if you look at the material on which you're walking. Real horizontal strata gave us a vocabulary, which is an essential component in any work of architecture – I think in any work of art. To know the vocabulary you are using in your building allows you to begin to make decisions that are consistent with each other. Like a grammar.

Campbell: It's fascinating to me that what I call the governing metaphor grew out of this process; it was not some thing you dreamed up and imposed on the project.

Silvetti: I mentioned that there was an early manifestation of the metaphor, but it was in a purely poetic way, more or less a writing. It was somewhat forgotten, but then reappeared when we realized we would have the retaining walls and knew that people would enter from above and look down into something.

Campbell: For me, the single boldest thing that you did was put the outdoor theater face to face with the facade of the temple, the Villa, which creates a moment of centeredness and energy that I think is extraordinary.

Silvetti: Early on we realized that there would be a trap in this project – if our pursuit was to restore authenticity to the Villa. This building is not a villa from antiquity; it's a building from the twentieth century. Rather than striving for an authenticity that it could never have, we decided that this building needed to create an atmosphere that would evoke and provide a setting for the display, study, and enjoyment of the art of antiquity. The idea was to do that, but not to try to build something as close as possible to a Roman villa, in part because nobody knows exactly what the villa from Herculaneum looked like. And, of course, it was a house, not a museum.

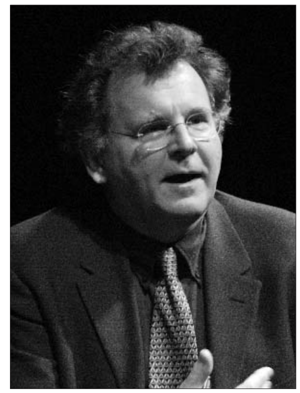
The Getty has a good, successful program of ancient drama every summer, so somewhere on the property we had to incorporate an outdoor theater modeled on a classical theater. Our first attempt – it was fantastic – was to put the theater up in the hill. The property is very big (it's 60-some acres), and it goes fast up after the house. The theater would have been really high up, with the Pacific as the background and the proscenium below, with the Villa at your feet. It would have been spectacular, but that idea, even for the Getty, was a little too expensive. We knew then we needed to put a theater somewhere, and, particularly, somewhere that was easily accessible to the many people who come to public functions hosted at the Getty.

Campbell: And the Villa becomes the set?

Silvetti: Exactly. It's been very rewarding to see two different companies in the last two years stage classical plays in the theater, with the Villa, the portico, in the background.

Campbell: Let's turn to the question of conservation. The common ground between Jorge Silvetti and Jerry Podany is conservation. How did you consider conservation in your design?

Silvetti: In the construction, Jerry and I worked together on many features of the design of the Villa because there are aspects of the architecture that are directly related to conservation: considerations of how the building is built and how that might affect artifacts. That part of the collaboration helps illuminate what was at stake in this building, in the renovation.



Jerry Podany

Jerry Podany is Senior Conservator of Antiquities at the J. Paul Getty Museum. He is also President of the International Institute for Conservation of Historic and Artistic Works.

Presentation

What Jorge is referring to is one of the greatest threats we face here in Southern California: if you look at a chart of the numbers and intensities of earthquakes around the world, a lot of that data focus on Southern California. This is a great concern to us, and we've spent a number of decades and a great deal of effort to try to protect the collection from earthquake damage, leading to a lot of research and collaboration with engineers and scientists. We learned how to protect individual objects and cases, using specially designed mounts and base isolators that allow the earth to move freely under the object and the object to remain unaffected.

The renovation gave us a wonderful opportunity to look at the structure of the building. The Villa Museum is an incredibly stable building: it's built essentially on bedrock, the walls are hugely thick, and it will move with the earth during an earthquake. Our attention, then, really is on the contents, the collection. We were able to strengthen a number of the floors and embed anchoring systems behind the walls for hanging objects. There are also anchor points that Jorge's team incorporated into the design of the terrazzo floors. As you go into the galleries, you see regular repeated circles or squares in these designs. These are covers for anchor points. The covers lift up and allow us to secure pedestals or objects to the gallery floor.

Jorge and I had a very interesting conversation about how numerous and how strong the wall anchors should be. Jorge asked, "What's the heaviest object you'd think about hanging there?" and I said, "Oh, three or four tons." "Three or four tons? Are you crazy? That's like a Volkswagen," he replied. However, in the first year of our new Villa, we had a series of monumental mosaics from Tunisia that were very close to that weight. Now we're able to put objects like these up safely and easily.

Our work involves not only restoration and responding to the needs of individual objects on display, but also questions of authenticity, issues of material science, preservation, and preventative conservation.

Campbell: Could you say a word about the objects? I am particularly interested in this question: to what stage of its life do you restore a particular object?

Podany: Most of our collection came from the marketplace, so the majority of the works have been restored or treated at some point in the past – all the way back to the eighteenth century in some cases. We're doing a project with Dresden right now that involves a wonderful object that was excavated, and entered the princely collections of Dresden in the late seventeenth century, and was restored as an Alexander the Great. However, that ended up to be the wrong restoration (it's an Antinous or Dionysus), so it had three different restorations between its discovery and the nineteenth century. During the war it was taken off to Moscow as war booty, and a train accident left it in about 150 pieces . . . until just recently, when we brought it here to the Getty. The debate now is, when we re-restore and repair the object, should it go back to the Baroque restoration or the nineteenth-century restorations – or should it be restored at all, or restored again but in a new way, since we now know more?

Campbell: What is the decision-making process then?

Podany: The decision-making process in a lot of these situations, but particularly with the Dresden object since it's not ours, is to gather together as many people as possible, who have particular ideas to bring to the table – scholars, scientists, and geologists, as a start. We work with many people and manage all of that input, all for the sake of long-term care and preservation of the collection.

Campbell: So that raises the question of what is conservation?

Podany: Conservation is a matter of stabilizing an object. Restoration, in its traditional definition, is bringing an object back to what it might have looked like originally, based on the state of knowledge at the time. Of course, that denies its entire history, and most of the time early restorations involved a lot of imagination, which led to a lot of misunderstanding. Conservation takes into account the issue of restoration, but it increasingly takes into account preservation: trying to make sure objects last as long as possible but are also accessible – which is sometimes contradictory.

Our work involves not only restoration and responding to the needs of individual objects on display, but also questions of authenticity, issues of material science, preservation, and preventative conservation.

Campbell: I'm curious about the issue of forgery. Someone once told me that a forger can fool only his own generation, because later generations will see the original in a different way and forgeries will be spotted much more easily. Do you think that's true, and is it true of the Getty's objects?

Podany: I think it's true of the pieces that we've discovered to be forgeries. I think there may well be objects in galleries and museums across the world that are extraordinary forgeries, in which the forger has learned to overcome his or her own time. But I also think that there may well be a number of pieces that have been condemned as forgeries because they didn't present what the art historian, the scholar, or the archaeologist was used to, and as a result they've been hidden for a period of time, taken off view, but could very well be rediscovered again.

Campbell: These are fascinating subjects, and they all raise the question of what we mean by *conserve*, *conservator*, and *restore*: all of these words are so complicated that seem so simple. Other than by making objects safe – by ensuring, down to the foundations of the building, that nothing would ever be moved or damaged – how did you think of presenting these objects within the museum?

Silvetti: Through a fantastic process of collaboration. The way the museum operates as a museum, that is, the way it displays its objects, is not entirely our idea. The project alone was three years long, but it really took 12 years in total, working with, among others, Marion True and her staff. The museum was a project in itself, and we all worked together. The design of the cases was particularly collaborative. I always call them the Rolls Royce of cases because on the outside they are very good looking, but inside they have this incredible machinery that you can't see.

Campbell: They're climate controlled inside, are they not?

Silvetti: Yes, and they have the amazing capability to balance earthquakes. Some of the objects are floating, although you don't notice that. If there is movement, the rest of the world moves; they don't.

By collaborating so closely for so many years, we ensured that neither the architecture nor the objects take over one another. I think the harmony of the place is one of the most rewarding aspects of this unique process. It was always productive, and I learned so much. For example, for all of my years in school and all the things I've done in my life, in my life of painting, I realize that I learned color doing this project. I learned it because I brought my own knowledge, but I was surrounded by people who knew as much and more than I did.

Campbell: Do you mean the historicity of color? What aspect of color?

Silvetti: Color is one of the most difficult things. Everyone in the art world knows that there is the science of color, but, in the end, you either have it or you don't – the idea of how to combine colors and how to put them together. Here I worked with people with an extremely well-developed, sophisticated sensibility for colors. (Marion, in this sense, was spectacular.) In the museum, there were certainly technical issues that were really very difficult. But the color issue was one that probably involved the most hours – sample after sample, and testing and combining.

Conservation takes into account the issue of restoration, but it increasingly takes into account preservation: trying to make sure objects last as long as possible but are also accessible.

Campbell: Was this intuitive on your part, or were you trying to recapture colors that were traditional Roman colors?

Silvetti: Color, in my experience, can only be resolved by testing. You have to see it and then say what you think; you can't think of a color – at least I can't. Although we didn't paint, it was really hands-on. We were making these colors, changing them, accepting them, and sometimes trying again. It was a very long process.

Campbell: In the old Getty Museum, there were paintings. And paintings are damaged by sunlight. Now you have a museum in which, almost entirely, you have objects that are not easily damaged by sunlight. How did that affect the way you redesigned the building?

Silvetti: The amount of work and the transformation of the museum building are radical. I would say that high up on the list of things that changed so much is natural light. The previous Villa did not have natural light in any gallery. The windows you see in the atrium and around the inner peristyle were closed. They were fake blank windows, which we have now opened. In total, we opened approximately 60 windows and three skylights. The place is flooded with natural light, which provides that very rich sense of liveliness that natural light gives because it changes every second.

An additional benefit of the windows, something we didn't necessarily think would be a result, is that they help orient you everywhere you are: you see across, you see out, you see people that you saw five minutes ago, but you see them in the garden; you know exactly where you came from and where you're going. That's totally changed the experience of the building, which before, because it did not have any windows, was really more like a labyrinth. (But, of course, the Villa as it was then couldn't have natural light.) Most museums today are trying to bring in natural light, and there are some very successful ones that incorporate it in an indirect way. Here, though, it's direct.

Questions and Answers

Question: One of the most fascinating things I know about conservation activities under Jerry Podany's leadership has to do with a certain Russian krater. I wonder if he might relate to us the saga of the restoration of that Russian krater, the Boxy Krater.

Podany: While we were in Russia almost five years ago, looking at some objects for a loan for a special exhibition here at the Getty, we noticed the fragments of a wonderful and huge krater (a vase used as a mixing bowl). It was beautifully painted, but it was fragmentary. We offered to conserve this piece because we've developed a number of techniques, not only for sculpture, but also for ceramics and bronze, that are now internationally accepted as procedures in conservation. We wanted to apply these techniques and train some of the St. Petersburg conservators.

We started the process – as you can imagine, it takes a very long time to work through all the bureaucracy – and we thought we were almost there: the object would come, we would assemble it, we would re-create its basic shape, we would have an exhibition, there would be training. But we reached a point where customs officials just couldn't get around the possibility that they would send us 30 things (that is to say fragments of a vase) and get only one back (the restored, assembled vase).

We now have an incredible project with Berlin. Some absolutely monumental and beautiful south Italian vases, half of which are being conserved in Berlin, and half will be conserved here. These will come together for an exhibition here at the Getty Museum. It will be stunning and spectacular – and we won't have the same customs problems.

Question: What sorts of chemical and physical tests do you apply to determine authenticity of ceramics or sculptural things? How do you know they're not fakes?

Podany: It's both an art and a science. There's a whole range of tests that can be done for ceramics, including thermoluminescence, and for organic materials there's carbon 14. There's nothing for stone, but there is an understanding of what a surface should look like if it has undergone the kind of weathering that would be expected in either burial or exposure for thousands of years.

If stone has been restored and cleaned with acid, it's another story. All the evidence of age has been removed. Then it becomes a matter of comparing it to a database, like art historians do: looking at what we know to be authentic, what it looks like, what are the working techniques, what's the approach to sculpting – there's really quite a range. While some things are absolute, other things are not quite so sure. You build a pile of evidence that weighs more heavily in one way, either for its authenticity or lack thereof.

Question: You spoke of your discoveries about color, which led me to think about light, and the light here compared with the light of, say, Herculaneum. It strikes me that they may be quite similar. But did you do a lot of thinking about differences in the ambient light and the colors, and how did you try to deal with the issue? Did you try, in effect, to make adjustments for the differences in the light?

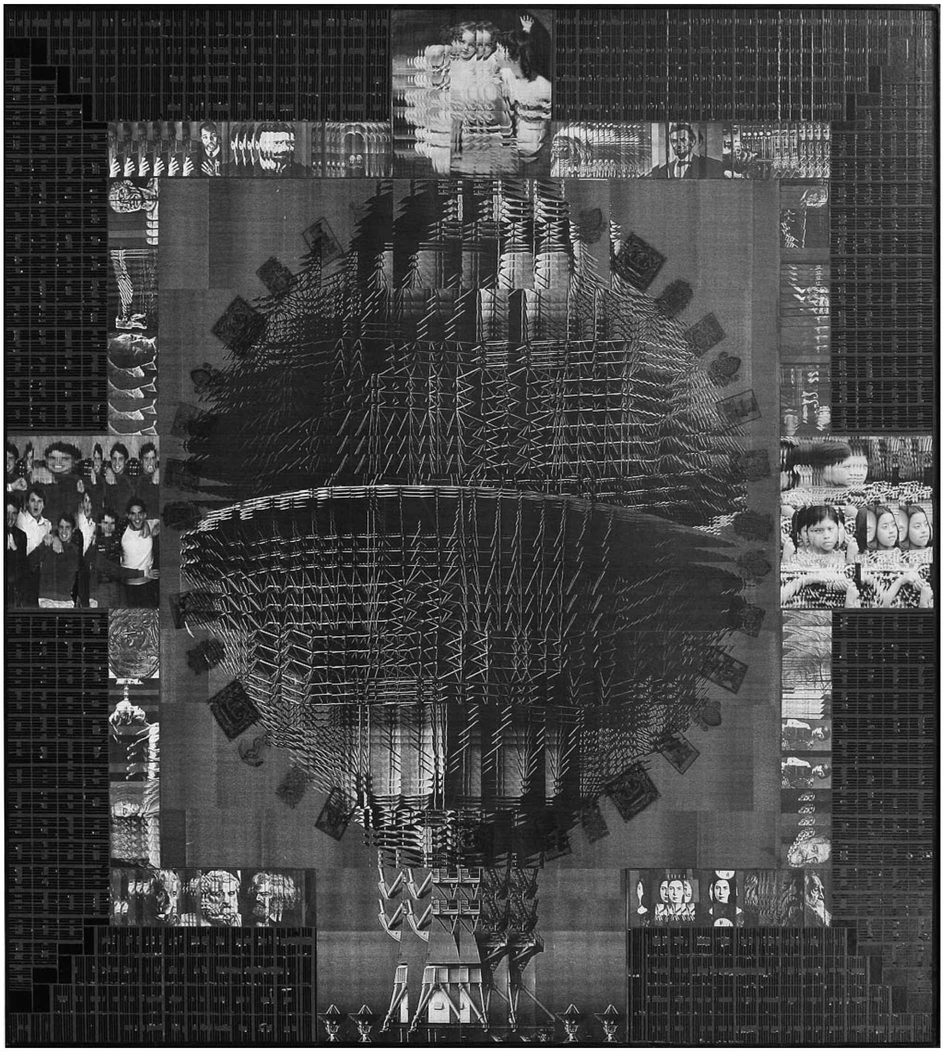
Silvetti: No, we were not after what I think is a very elusive, if not wrong, objective: re-creating exact conditions. I think that's impossible. It was more about creating an at-

The Villa is flooded with natural light, which provides that very rich sense of liveliness that natural light gives because it changes every second.

mosphere, an evocation. We did make two extensive trips, one to museums of antiquities in Europe and another to Italian sites – Pompeii, Herculaneum, Hadrian's Villa – to see as much as we could of the experience of everything in those houses. Of course, color in some of the houses in Pompeii is quite vivid, and you learn a lot. We have more than 40 color studies that we did of actual walls. Styles of Pompeian painting are fairly elaborate in terms of ornamental decoration, but they also deal with very bold combinations of colors. We were not trying to create the murals and these representations, so we knew we were going to deal with abstract colors, not with highly ornamented decoration. We did study percentages, for instance, of what colors combined with what in this way.

It's more perceptual than scientific. It was looking at something, recording, and then studying what was that combination. But, again, while we did not try to reproduce anything, we did learn from direct experience. Visiting the European museums was probably the eye-opener. Surprisingly, one of the places that impressed us the most in terms of lighting and color was not in Italy, but in Denmark. The Ny Carlsberg Glyptotek has fantastic natural light. It's a very different light than the Mediterranean light, but at the Glyptotek they managed to create a wonderful ambience for the art, with vivid classical wall colors, too. This comparison of museums proved very rich. ■

Members of the Western Council at the Getty Villa: Vice President Jesse Choper (University of California, Berkeley), Ernest Henley (University of Washington), Edward Feigenbaum (Stanford University), Charles Hirschman (University of Washington), Eugene Wong (University of California, Berkeley), Gordon Gill (University of California, San Diego), and Melvin Simon (California Institute of Technology). Not shown: Elizabeth Blackburn (University of California, San Francisco), Richard Easterlin (University of Southern California), and Saul Friedlander (University of California, Los Angeles)

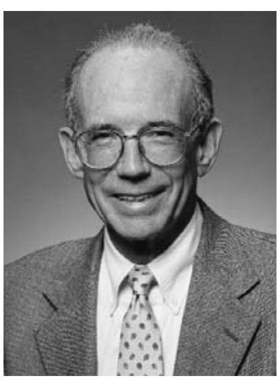


Science, Policy, and the Media

Donald Kennedy

This presentation was given at the 1923rd Stated Meeting, held at the House of the Academy on February 13, 2008.

Collage by Samuel E. Gallo titled *Media Message People*. The media are symbolized by the spherical center section, which suggests a world interconnected by media networks as complex as the human nervous system. Printers' marks surround the sphere. The human elements are represented in the three square panels at the edges of the collage. Along the outer band, portraits of famous people are accompanied by the people's messages written in a computer code used to translate words into binary numbers. Photo courtesy of University of Oregon School of Journalism and Communication.



Donald Kennedy

Donald Kennedy is Editor-in-Chief Emeritus of Science *magazine, and President Emeritus and Bing Professor of Environmental Science and Policy Emeritus at Stanford University. He has been a Fellow of the American Academy since 1968.*

Geneva Overholser (University of Southern California) and I have been engaged with a fine group of colleagues in thinking about an old and sometimes difficult topic: the relationship between journalists who report science and scientists who do the science on which they report.

We are not the first group to have tackled this problem, nor do we seriously expect to have the last word on it. We have had wonderfully thoughtful written analyses by some of those involved in the transaction – science journalists like Corey Dean, Boyce Rensberger, and Bob Bazell; scientists like Tom Lovejoy and Dan Schrag; and public information officers like Earl Holland and Rick Borcheldt, who are often found near the center of such exchanges. Our committee has proceeded with some enthusiasm because we think scientific understanding is a precious resource for society and because we believe the interface for scientific communication can be improved.

Why is this issue worth so much attention? I want to start with the proposition that a broadly spread citizen-understanding of science and technology is a public good, and that we really can't have too much of it. Several arguments support that proposition. First, we are a curious people, equipped with a lively sense of wonder. Knowledge about the natural world should be absolutely on a par with knowledge about the arts and humanities, though unaccountably it is often given second place on the liberal arts menu. Second, in any given year, our democracy has to decide a host of issues that have important scientific and technological content: what to do about climate change, how to organize human or robotic exploration of space, how to develop a sustainable national energy policy, how to treat the health potential offered by embryonic stem cells, and the like. To vote intelligently, citizens increasingly will require a level of scientific literacy. Finally, we need to develop a layer of committed scientists who will lead the march of discovery, providing the basic research findings that will be the seed corn for the next generation of developments. In making that kind of commitment, young people are often inspired by dramatic research accomplishments – ones that are being made by scientists and interpreted by those who write about the work.

Those are the three legs of the stool that support science in our culture, and they all depend on this singularly important relationship between scientists and science journalists. There are a number of respects in which that relationship is in good health: the best reporters have learned a lot of science, and the best scientists have forged productive relationships with journalists.

What is the relationship between journalists who report science and scientists who do the science on which they report?

Nevertheless, complaints are being heard from both sides – enough to encourage a kind of caricature of misunderstanding. Scientist A complains that the reporter hasn't taken the trouble to get some background on climate change science, and he has to be educated from scratch. After a certain amount of that, the reporter writes a story in which A's view is paired with criticism from a person who denies global warming. "The trouble with these guys," A says, "is that they each have a two-card Rolodex with an IPCC name on one and Fred Singer's name on the other." The journalist might point out that had scientists in this area been both more careful and more understandable in describing the underlying issues to journalists, it would not have been necessary for A to deliver a cram course to a reporter with a short deadline. As for the two contending views, it may be asking too much for journalists to count the ayes and nays for every issue – although in the climate change case there is some ground for the scientists' complaint.

A second concern revolves around a disturbing question: Is science writing a disappearing culture? Cristine Russell contributed a poignant piece in the journal of the National Association of Science Writers. In it she describes the demise of the science page – in its time a very good one – at *The Baltimore Sun*. The number of sections or departments dedicated to science in major American metropolitan dailies is estimated to have fallen by half over the past ten years, as declining newspaper economics has tightened its grip. Even at *The New York Times*, with its splendid staff of science writers, we fans have watched its excellent Tuesday Science section morph gradually from mostly science to mostly health.

At *Science* we face some interesting choices because we have some of each: a number of very well-trained and careful science writers in our News department, which has sent several of its alumni to *The New York Times* and National Public Radio, and a couple dozen editors who are all well post-PhD in their disciplinary specialties. Every week the two groups meet to decide which of the papers we plan to publish will be covered by the News section, and which, instead, will be covered by a Perspective, written by a scientist recruited by the editorial staff. Blood is never shed on these occasions, but sometimes problems follow. The purpose of the Perspective is to look at the broader field to which the paper contributes; it is written by a scientist who knows the field well and can establish a context for the new findings. If News covers the paper, our writer may ask questions that might challenge the judgment of an editor. It happens occasionally, but we maintain a clear separation: editors don't tell writers who the peer reviewers are, and our writers don't ask editors who ought to be contacted or avoided.

In pondering the understandings and failures of understanding that occur when scientists from, let's call it, the University of Midwest are talking to journalists from, say, the *Capitol Star*, our committee has tried to surface some common themes. The scientist thinks

A broadly spread citizen-understanding of science and technology is a public good.

that her discovery is important, and with great enthusiasm she describes the problem and her experimental solution of it. The journalist, for whom the science beat comprises only a small part of his portfolio, has little knowledge of the context for his interviewee's work and cannot judge its significance.

To check things out, he calls the Public Information Officer (PIO) of the university to get some background. This particular PIO has prepared a press release after discussing the work with the investigator and her colleagues and is able to supply the journalist with what he needs. Part of the release is clearer to the reporter than the investigator had been; being on short deadline he makes use of a paragraph from the release as the lead for his story, but adds additional material he had absorbed from the researcher's account. The story appears the next morning with the headline "U Mid Researcher Finds Gene for Muscular Dystrophy."

The story initiates a brisk conversation between the researcher and the journalist. The former points out that the gene relates to a mouse model of muscular dystrophy, and that what she had actually found was a site on one chromosome that probably contains the gene. The journalist blames the headline writer, pointing out that the text of the story is far more realistic – save perhaps for some modest overreaching in the part of the press release he had quoted, which naturally he blames on the PIO. No one is left entirely happy with the outcome.

I confess that this is not only hypothetical; it is a caricature. But it is a realistic scenario for understanding the roles played by different actors in this complex and challenging relationship.

If it can't be worked out, what have we lost? Public understanding of science, as I said in the beginning, is a major social good. Understandable and inspiring writing about science changes lives: Consider the number of young men and women whose passion for nature was stirred by Rachel Carson's *Under the Sea Wind* or, much more recently, by David Quammen's *The Song of the Dodo*. Or consider the kids in Los Angeles who started thinking about the cosmos because K.C. Cole's books, based on her *Los Angeles Times* pieces, touched their curiosity. Beyond the value inherent in the creation of an inquiring citizenry, there is another case for public understanding of science. Important social decisions have to be made wherever science and technology have a powerful impact on prospective public policies. Support for those is dependent on voters who can sort out that relationship and evaluate the science.

That, in turn, depends heavily on what the scientists say and how carefully they say it, and on the journalists who record and interpret the outcome for the public. We are working to improve that relationship – not be-

Knowledge about the natural world should be absolutely on a par with knowledge about the arts and humanities.

cause we think it's in trouble, but because we think it is important enough to pay attention to. Since we have arrived at the science-policy junction, I'd like to explore a case in which various forces – some natural, some human – tend to make the move from science to policy difficult.

There is hardly a clearer venue where science is interacting with policy formation than in the case of climate change and what to do about it. The Intergovernmental Panel on Climate Change (IPCC), a joint project begun twenty years ago as a collaboration between the United Nations and the World Meteorological Organization, has assembled a large body of the best climate scientists from around the world. Their reports contain not only information on the status of the science – drawing on atmospheric physics, oceanography, paleoclimatology, and other disciplines – but also sections on adaptation and mitigation strategies from groups that include economists and other social scientists. In each year in which the IPCC reports, there is a summary for policy-makers in which the IPCC conclusions are tested against official views of national governments and others to produce a consensus document that may be marginally more cautious than the views of the scientists. That nuance of process, well understood in the climate change science community, may be lost in published accounts of IPCC findings.

The general conclusions relate the increase in average global temperature already experienced – about 0.7 degrees Celsius – to the increase in greenhouse gases (especially CO_2, which has risen from a preindustrial level of 280 ppm/v to the present 385 ppm/v) that have resulted from human activity. The conclusions are also firm in supporting the use, for projection, of general circulation models that predict a gradual increase in average global temperature, reaching somewhere around 2.5 to 7.0 degrees Celsius by the end of the century, accompanied by a sea level rise of 20 to 82 centimeters and an increase in the frequency of extreme weather events. A small number of scientists in the field disagree with the IPCC consensus. Some believe that the consensus understates the rise in sea level. Others deny its more general conclusions, and are joined and sometimes supported by interests that do not wish to see a strong regulatory policy outcome that will have significant economic consequences.

A journalist following this story has to deal with a number of circumstances. First, it is a big story: an overwhelming majority of the American public now believes that climate change is a major problem and poses a serious threat to our future. So the question of who is right about the science is a big, important question. Second, she will encounter well-credentialed scientists who have deeply held, even passionate, views on the subject. Most will be strong advocates for the IPCC-consensus and wonder why a journalist would consider another view. Others, fewer in number, will cite histories of natural fluctuations in world climate, or challenge the utility of the models, or point to other work that, in their view, makes the scientific position on global warming "controversial."

Under those circumstances many good reporters will consider it fair and reasonable

To vote intelligently, citizens increasingly will require a level of scientific literacy.

to discuss the matter with several people on each side. No problem there. But the IPCC consensus involves hundreds of scientists, and its conclusions all rest on research published in peer-reviewed journals. Historian of science Naomi Oreskes, at the University of California at San Diego, analyzed the consensus on climate change in this way four years ago; the 2008 consensus is far stronger:

> In its most recent assessment, IPCC states unequivocally that the consensus of scientific opinion is that Earth's climate is being affected by human activities: "Human activities . . . are modifying the concentration of atmospheric constituents . . . that absorb or scatter radiant energy . . . . [M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations ."[1]
>
> IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise bears directly on the matter have issued similar statements. For example, the National Academy of Sciences report, *Climate Change Science: An Analysis of Some Key Questions*, begins: "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise." The report explicitly asks whether the IPCC assessment is a fair summary of professional scientific thinking, and answers yes: "The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue."
>
> The drafting of such reports and statements involves many opportunities for comment, criticism, and revision, and it is not likely that they would diverge greatly from the opinions of the societies' mem-

[1] Naomi Oreskes, "The Scientific Consensus on Climate Change," *Science* 306 (2004): 1686.

> bers. Nevertheless, they might downplay legitimate dissenting opinions. That hypothesis was tested by analyzing 98 abstracts, published in refereed scientific journals between 1993 and 2003, and listed in the ISI database with the keywords "climate change."
>
> The 928 papers were divided into six categories: explicit endorsement of the consensus position, evaluation of impacts, mitigation proposals, methods, paleoclimate analysis, and rejection of the consensus position. Of all the papers, 75% fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25% dealt with methods of paleoclimate, taking no position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.

In fact, I count today about six scientists who regularly appear in opposition to the consensus, and most of them do not publish original research. If the reporter has a short deadline, she may resort to one or two on each side. When this happens in the climate change arena, most people in the research community are horrified.

Is science writing a disappearing culture?

What should the poor reporter do? She should be concerned about two important attributes of scientists. The first is their qualifications: the journals they have published in and other credentials, including invited articles; membership in scientific societies and academies; and support from agencies that award grants on the basis of peer review – indeed, information of the kind she might get by taking advantage of such sources as Oreskes indicated.

The second concerns possible financial conflicts of interest: a reporter could ask hard questions about whether the scientist is getting financial support and from whom. In this case certain energy companies and foundations – the Competitive Enterprise Institute, the Heritage Foundation, and the George C. Marshall Institute – have all supported scientists who actively publish critiques of the IPCC consensus. Support from those sources might raise questions that would not arise from a National Science Foundation grant.

There is another criterion. Is there evidence of a more organized agenda? Oreskes has studied, as has Robert Porter, the development of a particular strategy on the part of those who dispute the evidence for global warming. Early contacts were made between these individuals and others, including scientists, who challenged the epidemiological consensus on the relationship between smoking and lung cancer. The common theme of both campaigns, which the climate group learned from the tobacco scientists, is that one should "teach the controversy" – that is, present the underlying science as unclear because there are scientists who have surfaced disagreements with the consensus. When that controversy is abetted by support from particular industries or foundations, money enters the picture again.

Of course, here is a danger in using guilt by association; conflict of interest or prospect of financial gain is very different from the matter of scientific competence. At *Science* we make authors declare all their support, and where any of it might suggest to the reader that a potential conflict might exist, we publish that information. But our determination of the paper's scientific merit is conducted independent of that, and we don't think the two should be confused. Some reporters are apt to make it a proxy for serious judgments about competence, and that may mislead the reader.

Neil Munro, a Washington investigative reporter who works for *National Journal* off and on, warns reporters to include outside financial sources when writing about academic researchers. For example, in a piece called "Doctor Who?" in *Washington Monthly*, he compares two biologists who work on stem cells. Dr. David Prentice of Indiana State University believes that all the medical promise of stem cell research can be met with adult stem cells; on the other side, Dr. Irving Weissman of Stanford University is a partisan for the use of embryonic stem cells. "Part of the explanation, of course, is simply an honest difference of opinion among scientists," Munro says. But he then goes on to elaborate the financial advantages Prentice might gain from a biotech company he hopes to found, and the fact that Weissman has "made millions" in companies using stem cell technology. He points out that neither man has kept his affiliations a secret; his objection is to the press, which invariably refers to Weissman as "a biologist from Stanford."

Important social decisions have to be made wherever science and technology have a powerful impact on prospective public policies. Support for those is dependent on voters who can sort out that relationship and evaluate the science.

What interests me is Munro's role as a reporter. He takes care of a significant difference of opinion by explaining it in terms of financial interest and ignores evidence of a stark difference in competence. Weissman has published numerous articles in top-tier peer-reviewed journals, and is widely regarded as an innovative leader in cell biology. He is a member of the National Academy of Science (not merely a chair of one panel, the distinction Munro allows him), and a recipient of a number of prizes and awards. Prentice has no peer-reviewed publications; his website refers to a letter in *Science*, which was unreviewed and soon followed by a letter from three distinguished scientists contesting nearly every claim Prentice had made. All of this information was readily available.

Munro's advice to reporters, to disclose financial relationships, is good advice. It would have been better had it been accompanied by an admonition to follow the credentials as well as the money.

I have touched upon two of the matters that might figure in the debate about science that many of us hope will take place before the primary races get to the convention stage. Climate change and the stem cell debate are this year's poster children for scientific issues that converge with public policy, and of course that means that they're political. In each case, federal action has failed to follow public preference; the result has been a down-migration of jurisdiction – with states passing referenda to support stem cell research, California pushing its own emissions standards, and mayors organizing to reduce the carbon footprints of their cities. This interesting development ought to get more press than it does.

So should another problem: a growing scientific suspicion about the number of "fixes" now making their appearance in the climate-energy space. Biofuels, especially corn-derived ethanol, are not regarded by most scientists as workable – either economically or as carbon-sparing once every cost is in. An equal skepticism is attending the number of "carbon offsets" being made available to households, industries, or even individuals who have taken on a sense of obligation to reduce their carbon footprints. There are doubtless offsets that actually do achieve a carbon-neutralization effect – but these are rare and do not include random acts of tree-planting, or the fertilization of bits of ocean with nutrients that might produce blooms of phytoplankton.

An overwhelming majority of the American public now believes that climate change is a major problem and poses a serious threat to our future.

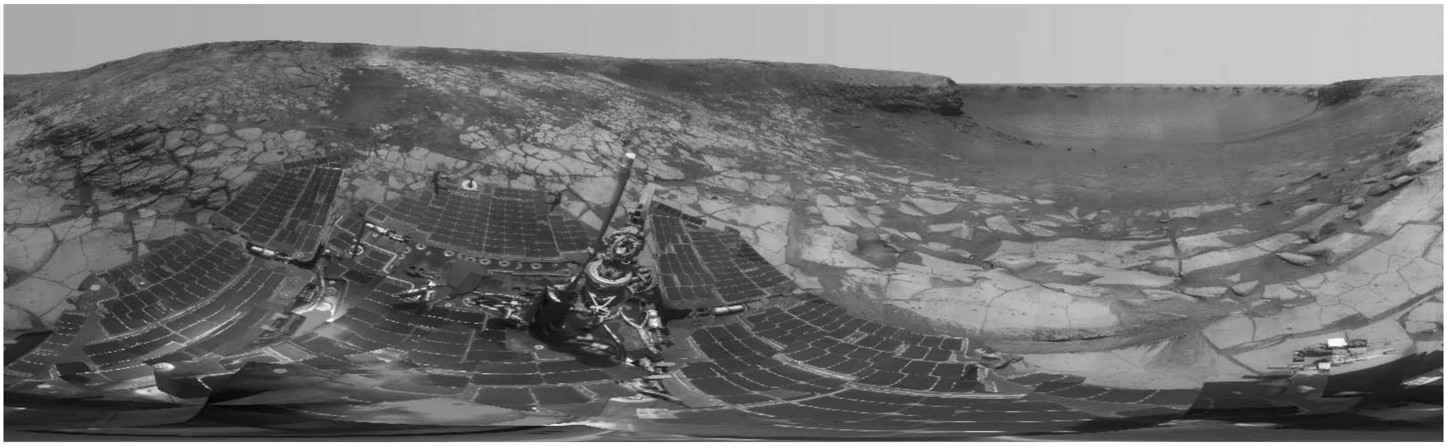
So far I have been emphasizing things journalists might do to create a more balanced and knowledgeable account of science for the public. But it would be foolish as well as unfair to put the entire burden on the press. Scientists need to do much more of the work themselves: by learning to speak more clearly about what they're doing, by getting out into the real world to talk more directly to the public, and by taking care to be scientifically sound and rigorous as they connect their own work to public policy.

A number of incentives make all this difficult to achieve. Scientists being trained in one of the iconic PhD-granting departments are seldom urged to work on their communication skills. Too many of their mentors are interested exclusively in their progress toward completion of a dissertation; a joke current in molecular biology is that they are determined to create clonal offspring. It is a commonly heard instruction to graduate students that instead of undertaking a course involving some kind of outreach, they should focus on the thesis. I once asked Bob Berdahl, the thoughtful president of the Association of American Universities, if it might be possible to find out how many science departments in universities that belong to the AAU offered seminars or courses on how to discuss science with the media or the public. He said he'd try, but predicted that the answer would be few or none.

The picture isn't actually quite that bleak. The Pew Foundation has sponsored some efforts of that kind, and the highly successful Aldo Leopold program has been coaching and teaching young scientists about media relations for some years. The best institutional Public Information Officers help their science faculties make press contacts, and often work to improve the clarity of communication between the two. But discouragingly little is happening at the great research universities, as Berdahl warns. Even worse then for a graduate student to be told – "That's a waste of your time; stick to your thesis" – is for his colleagues to warn him about the dangers of being "Saganized" – that is, to become popular enough as an explainer of science to risk the contempt of more serious researchers, a contempt that owes more than a little to envy.

A final problem that needs some discussion concerns resource concentration. The influential national media – concentrated heavily in the Boston-New York-Washington area – pay much more attention to science than do daily newspapers elsewhere, let alone cable television and talk radio. It is a natural consequence that some merging takes place between science and the media in these areas of higher concentration. It is hardly an accident that Corey Dean of *The New York Times* and Dan Schrag at Harvard are involved in a seminar that accomplishes just such a merger, nor is it surprising that Andy Revkin of the *Times* consults regularly at Harvard and Stanford about climate change science. In the long run, we are going to have to extend the business of relationship-making to some more disparate, less comfortable situations, in which we reach the majority of Americans with institutions and people and technologies we haven't yet connected. I wish I were a better example of what can be done, but I'm as limited as many of the rest of you. I hope the young scientist in the Leopold program and the young science writer from the *San Jose Mercury News* will be able to show us the way. ■

Scientists need to speak more clearly about what they're doing, by getting out into the real world to talk more directly to the public, and by taking care to be scientifically sound and rigorous as they connect their own work to public policy.



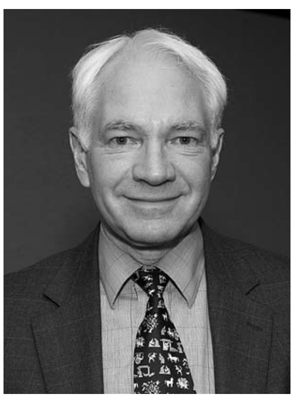
Panorama inside Victoria Crater, taken by a camera on the Mars Exploration Rover *Opportunity*. Image courtesy of NASA/JPL-Caltech/Cornell University.

Science Results from the Mars Exploration Rover Mission

Steven Squyres

Introduction by Claude Canizares

This presentation was given at the 1926th Stated Meeting, held at the House of the Academy on April 9, 2008.



Claude Canizares

Claude Canizares, a Fellow of the American Academy since 2004, is the Bruno Rossi Professor of Physics and Vice President for Research and Associate Provost at the Massachusetts Institute of Technology. He is also Associate Director of the Chandra X-ray Observatory Center and a Principal Investigator on NASA's Chandra X-ray Observatory.

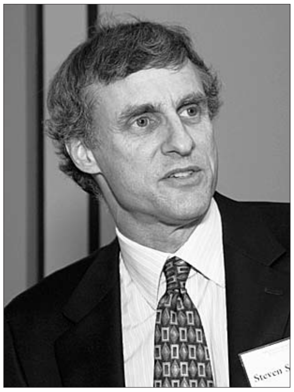
Introduction

It's a great pleasure, indeed an honor, to introduce my friend Steve Squyres. Just over four years ago I had the privilege of being at the Jet Propulsion Laboratory at the California Institute of Technology a few days after New Year's Eve, when the Mars Exploration Rover Mission reached Mars and went through the harrowing and exhilarating process known as entry, descent, and landing. This, of course, was wildly successful and it was the culmination of many years of effort by our speaker tonight, who is the Principal Scientific Investigator of this remarkable project. The two Rovers, *Spirit* and *Opportunity*, that are the scientific core of this mission have vastly exceeded by many times over their original design criteria and have returned an outstanding mother lode of information on Mars and its surface.

Even those of us who have lived through our own space missions recognize that the degree to which this mission has captivated the world is almost unprecedented: We can only marvel at the incredible scale, both scientific and technical, of the achievement. Steve Squyres really stewarded this effort through many years of development. Now, after probably thinking he had only a few years of operations and then a release onto other things, Steve is being called back over and over again to plan the very detailed activities of the two Rovers as they scour the surface of Mars.

In 1977, when Steve was an undergraduate at Cornell, the *Voyager* spacecraft was launched to Jupiter and Saturn. He, probably even as an undergraduate but certainly as a graduate student (also at Cornell), ended up participating in the scientific team for that mission, which became a galvanizing moment for him and set his career toward the planets, both the outer planets but then the inner planets as well. He participated in the Magellan Mission to Venus and the Cassini-Huygens Mission to Saturn; he, too, has touched most of the missions to Mars: the Mars Observer, the Russian Mars '96, Mars Express, Mars Reconnaissance Orbiter, the Mars Odyssey Mission, and, of course, the Mars Exploration Rovers.

CBS News called Steve the Mars Ambassador. Now, I don't think they meant that he himself is a Martian. Rather, he has brought Mars to the Earth, and without any question he is Earth's ambassador to Mars. It gives me great pleasure to welcome Steve Squyres.



Steven Squyres

Steven Squyres is the Goldwin Smith Professor of Astronomy at Cornell University and the Principal Scientific Investigator of NASA's Mars Exploration Rover Project. He has been a Fellow of the American Academy since 2005.

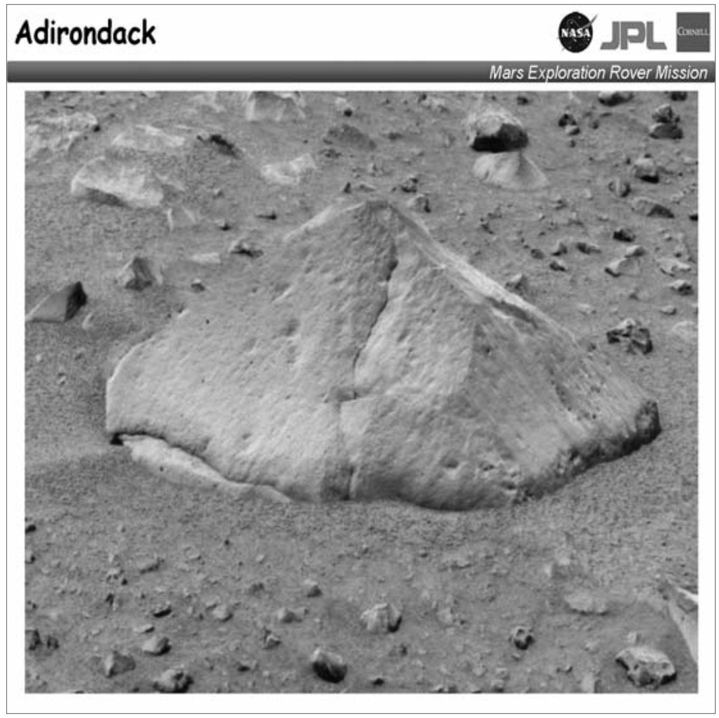


Figure 1

Presentation

I face the challenge of trying to compress a combined 3,000 days on the surface of Mars into less than half an hour, so fasten your seatbelts.

The two Mars Rovers, *Spirit* and *Opportunity*, are effectively robotic field geologists. They have a two-part scientific payload. One part does remote sensing, which is supported by a mast with high-resolution color stereo cameras at the top and a Michelson interferometer and infrared spectrometer that live down toward the base; they use mirrors at the top of the mast to get the same view of the countryside as the cameras get. The second part is an arm in the front end of the vehicle, a five degree of freedom robotic manipulator, that includes a microscopic imager, an alpha particle X-ray spectrometer that does elemental chemistry, a Mössbauer spectrometer that tells us about the mineralogy of iron-bearing species, and a device called the RAT, or Rock Abrasion Tool, a diamond-tip tool that grinds away the outer layers of Martian rock and exposes the interior.

Spirit landed in the Gusev Crater. At 160 kilometers in diameter and 16 degrees south latitude on Mars, the Crater was chosen as a landing site because of a large, water-carved channel that empties into it. We went there seeking layered sedimentary rocks laid down long ago on a Martian lake that we believe once filled the crater. After we landed I managed to convince myself for about two days that this was what a Martian dry lake bed should look like, nice and smooth and flat. But when we started to look at the rocks we found that they were not sedimentary rocks at all.

The two Mars Rovers, Spirit *and* Opportunity, *are effectively robotic field geologists.*

We named the first rock that we looked at in detail Adirondack (see Figure 1). A Mössbauer spectrum revealed olivine, pyroxene, and magnetite, among other minerals, in the Adirondack rock. (Olivine and pyroxene are minerals that would be very common in basaltic lava on Earth.) Our infrared spectrometer also revealed olivine and pyroxene, as well as plagioclase, another mineral found in basaltic lava. The mineralogy inferred from elemental chemistry, as derived from the X-ray spectrometer, showed, again, plagioclase, pyroxene, olivine, and a bit of magnetite. All of the instruments tell the same story: Adirondack is a magnetite-bearing olivine basalt. It's an igneous rock that was erupted onto the floor of the Crater, burying whatever sediments were once there. Basically Mars faked us out; this was a disappointment at first.

Our vehicles were designed to last for 90 Martian days and drive 600 meters over their lifetime. When *Spirit* landed, we came to rest 2.5 kilometers from a spectacular range of hills that we named the Columbia Hills, after the *Columbia* space shuttle. Because of the longevity of the vehicle, we were able to get to the Columbia Hills and spend most of the mission there. The first hill that we chose to go after was one that we named Husband Hill, after Rick Husband, who was the commander of *Columbia* when it went down. We climbed over a period of about 400 days to the very summit of Husband Hill, which gives you a sense of the scale of that hill.

I have nowhere near enough time to describe to you the incredibly rich diversity of different geologic materials that are found on Husband Hill and all the geologic stories they tell. I'll tell you just one, drawn from the first rocks that we found as we arrived at Husband Hill, on the portion of it that we called the West Spur. In contrast to what we saw on the plains – massive lavas – we started to see layered rocks, even sub-centimeter layering within the rocks, at the West Spur. Typical rocks from the West Spur are granular, with individual grains within the rock. There's enormous variety in the size of the grains: some are tiny little things that approach the resolution limit of our camera (30 microns per pixel); others are millimeters in size. The combination of small and large grains points toward a very violent, energetic process involved in the formation of these rocks. A gentle process like flowing water or blowing wind tends to have a particular grain size that it transports most effectively, so grains tend to be well-sorted and more or less the same size. A violent process like an explosion will throw out fine and coarse grains all together, resulting in a jumbled-up rock like we found at the West Spur.

We took the composition of these rocks and ratioed them on an element-by-element basis to compare them with the lavas that we saw on the plains. For some of the elements, the composition is fairly similar, but there are a number of elements, notably phosphorous, sulfur, chlorine, and bromine – elements that tend to be present in salts – that are substantially enriched in this rock from the West Spur. (The rock is also significantly enriched in nickel, to which I'll return later.) Mineralogy from our Mössbauer spectrometer found goethite, an iron oxihydroxide. The hydroxide tells us that water had to be involved in the formation of this mineral.

Taking all of this together, we've come to the conclusion that these rocks are impact ejecta that have been altered by water. When an impactor from space comes in, hits the surface, creates an explosion, and throws a bunch of stuff in the air, it all falls out at once, with some of the impactor itself mixed in. Impactors tend to be rich in nickel; we think that's where the nickel comes from. And then there's clear evidence that water altered the rock: the presence of goethite and deposited salts (which produced the sulfates), phosphates, and chlorides makes this obvious.

After time in the West Spur, we climbed all the way to the summit of Husband Hill and came down off the summit to a place called Home Plate, where we've been for a while. Home Plate is a plateau of layered volcanic rocks that is about two or three meters high and about 80 or 90 meters across. Right now we are on the north side of it, our solar rays tilted toward the north with the sun low in the northern sky, riding out our third winter on Mars. We hope to explore more with *Spirit* when springtime comes.

The right front wheel of *Spirit* no longer turns; it died about 800 days into the mission. The other five wheels work fine, but in order to drive the vehicle we have to drive it backward, dragging the broken wheel through the soil. While this does make *Spirit* hard to drive, it digs a trench, hundreds of meters long, through the Martian soil, turning up something wonderful every so often.

There's clear evidence that water altered the rock.

Opportunity came to rest in an impact crater we named Eagle Crater. We spent 60 Martian days there and then drove over to a much larger crater called Endurance Crater and spent a couple of hundred Martian days exploring there, including deep down into the crater. The *Opportunity* landing site was chosen not because of its topography but because of its chemistry. Data from an infrared spectrometer – the thermal emissions spectrometer that was in orbit around Mars on the Mars Global Surveyor spacecraft – show not only basaltic lava at the *Opportunity* landing site, but also hematite. Hematite, an iron oxide, is a mineral that sometimes forms as a consequence of the action of liquid water.

The rocks at Meridiani Planum, near where *Opportunity* landed, are all made of the same materials: they are sandstones, composed of sand-sized grains that are extremely rich in sulfate salts (see Figure 2). Embedded within them are little round spherules, things that we've come to call 'blueberries,' which turn out to be extremely rich in hematite. By mass, sulfate salts account for roughly 40 percent of the rock: 20 percent magnesium sulfate, 10 percent calcium sulfate, and 10 percent of an iron sulfate called jarosite.

When we mapped the composition with our infrared spectrometer we found a lot of sand made of basalt. The soils in many places are very rich in these hematite blueberries, but everywhere you have bedrock exposed, the rock is sulfate rich. The mineralogy derived from the infrared spectrum tells the same story as elemental chemistry: 10 percent jarosite, 20 percent magnesium sulfate, 10 percent calcium sulfate. The Mössbauer spectrometer sees only iron-bearing minerals, so it shows the jarosite as well. You need water to make this jarosite, a particularly environmentally informative mineral because it only forms at low pH. The pH has to be less than about four or five to form jarosite, and, on Earth, jarosite typically forms around a pH of three or two. This helps to make it clear that when people talk about the Meridiani Planum and the presence of water on Mars, they should more accurately be talking about sulfuric acid on Mars.

At Endurance Crater, the larger of the two craters where we took *Opportunity*, we drilled with our rock abrasion tool a total of eleven rat holes over a stratographic distance of about seven meters, working our way down into the crater. This is the first stratigraphic section ever put together on another planet. We saw some substantial changes in the nature of the rock as we went down. Toward the surface the rock preserved the lamina-

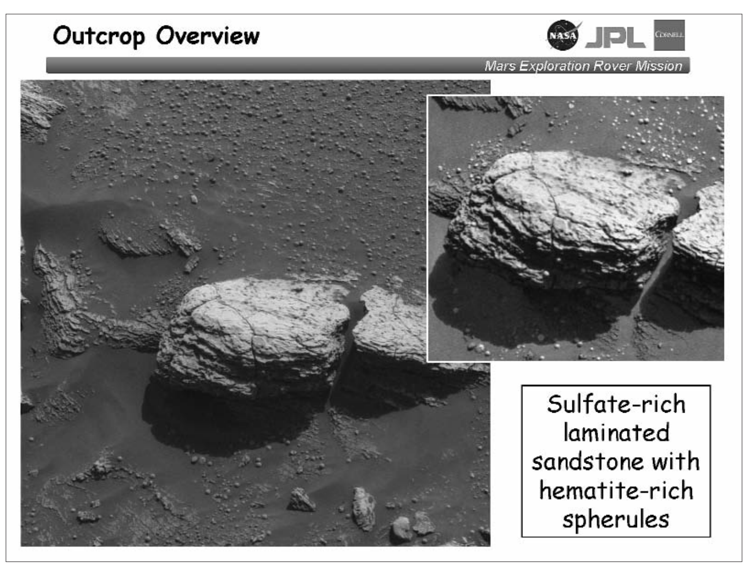


Figure 2

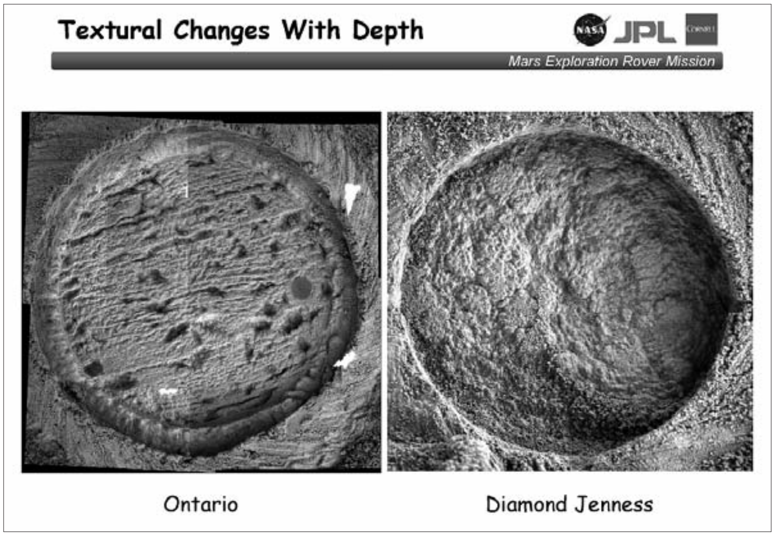


Figure 3

actually. We have concluded that they are concretions, which, on Earth, form in sedimentary rocks that are saturated in water. With a concretion, some mineral wants to precipitate out, so it finds a nucleation point and starts to solidify. It adds layer upon layer upon layer, growing a hard, spherical nodule (sort of like the way an oyster builds a pearl), which is dispersed through the rock. One interesting thing about a concretion is that as it grows, it draws fluid from a body of fluid around it within the rock and carves out a space for itself. This volume it creates for itself within the rock means that statistical analysis of the special or the volumetric distribution of concretions within a rock reveals a distribution that is not a poisson dis-

tions very nicely in the original layering in sandstone. But when we got deeper in the crater that changed completely. The layering goes away, replaced by a lumpy texture, which, we believe, is a consequence of recrystalization (see Figure 3). These are soluble rocks; magnesium sulfate in particular is highly soluble in water. If these rocks are soaked in water for long enough, recrystalization occurs, destroying the original textures. That is what you see deep in the crater.

The Opportunity *landing site was chosen not because of its topography but because of its chemistry.*

The chemistry changes as you go down-section as well. As you get deeper the chlorine increases sharply (precipitation of chloride salts is taking place below a certain level), but both sulfur and magnesium decrease. They follow each other beautifully, which tells us that the compound made of mostly magnesium and sulfur – magnesium sulfate – is the soluble material that gets dissolved away. The point at which the texture changes is the same point of depth below which the chemistry begins to change.

We found a place that we called the Berry Bowl, where a bunch of the so-called blueberries have come together (see Figure 4). We measured their composition and found them to be at least 50 percent hematite by mass – probably closer to 70 or 80 percent

Figure 4

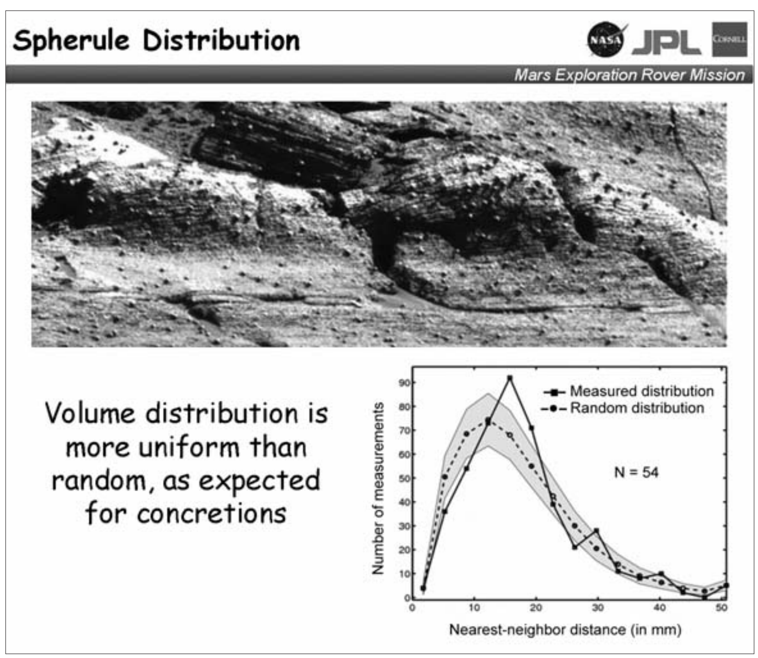


Figure 5

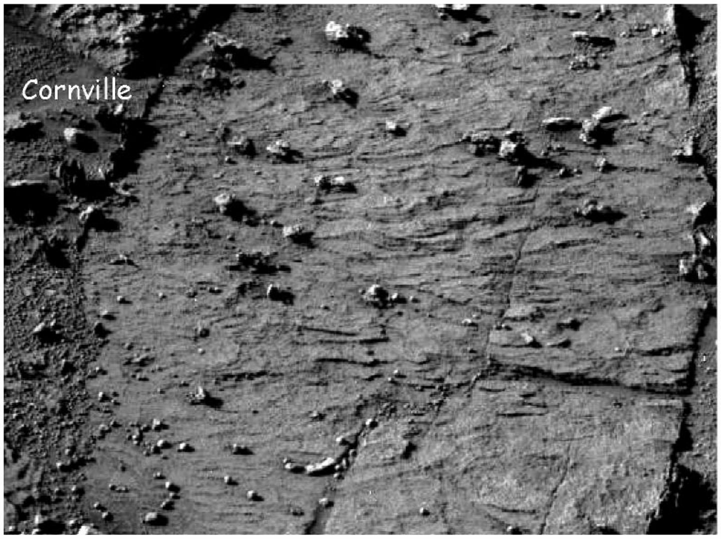


Figure 6

tribution, not spatially random but more uniform, because the concretions space themselves out; nearest-neighbor statistics of their distribution confirm this uniformity (see Figure 5).

Informed by data from experiments performed by Dave Rubin of the U.S. Geological Survey at Menlo Park, California, we have also found evidence in a few places that water not only saturated the ground but came to the surface. Rubin found that when water flows over sand that is 40 centimeters across it leaves behind highly sinuous crested ripples, at a scale of five to ten centimeters. Computer simulations (again, the work of Rubin) of a ripple crest propagating downstream show that what gets left behind in the geologic record are concave upward festoons or trough geometry cross-bedding structures, indicating that these ripples propagated downstream at very small scales and proving that water was the fluid that did it. We discovered concave smiley shapes within the rock, up to ten centimeters across, in a number of places, including a rock we named Cornville, which is chock full of these shapes (see Figure 6). So not only did water soak the ground here, but it also occasionally came to the surface.

I would be doing you a grave disservice if I gave you the sense that the science that I just described to you was science that was done by me. I am one member of a team of 170 scientists; I had 57 coinvestigators. It's an extraordinary team of scientists, and I'm very fortunate to be part of it. I also have to give a lot of credit to a fabulous team of engineers that built vehicles that were designed to last for 90 days and have lasted more than 1,500 days on the Martian surface. For every one of us who has been part of this mission, it has been, in the very literal sense of the phrase, the adventure of a lifetime.

When people talk about the Meridiani Planum and the presence of water on Mars, they should more accurately be talking about sulfuric acid on Mars.

Questions and Answers

Question: Where is the water now?

Squyres: We think that a substantial amount of the water is down in the ground, frozen as permafrost. There is a spacecraft called the Mars Odyssey Orbiter that carries a gamma neutron spectrometer which is able to detect ice deposits down to a depth of roughly 50 centimeters or a meter. Poleward of about 60 degrees latitude on Mars the ground is saturated with ice down to that depth. You can't see below that, but there's probably more down there as well. So a good bet is that a lot of it soaked into the ground and froze.

You have to realize that the Martian crust is a consequence of many events: it is a consequence of lots and lots of impact cratering. That cratering breaks up the rocks and causes a lot of fracturing and void space, much more than you would expect, perhaps, in terrestrial rocks. That provides a subsurface reservoir where a fair amount of water can be hidden.

Question: As you command the vehicle from mission control there are so many minutes, one-way transit time, before the vehicle hears the command and so many minutes for us to interpret the optical images that I presume get sent. What's the frequency at which these commands are issued? What's the experience like? What's happening in between communications? And how fast does the vehicle go?

Squyres: We operate the vehicles by sending a set of commands to them once a day. The sun rises on Mars and falls on the solar arrays, waking the vehicle, typically, at 10:30 in the morning, local solar time on Mars. We transmit to the vehicle a complete set of instructions, everything we want it to do that day. It works until about 4:30 in the afternoon, when the Mars Odyssey Orbiter flies overhead. At that point the Rover transmits to the Orbiter what happened that day, and the Orbiter relays the data back to Earth. We have roughly 18 hours to look at the data and images, figure out what we want to do next, and send the next set of commands to the vehicle.

I'd love to control the Rover via joystick, but we don't do it that way. When I talk about Rover "drivers," nobody has a steering wheel or throttle. Instead, we write hundreds of lines of computer code telling the Rover what to do each day. As for the speed of the vehicle, it can go six centimeters a second, but we don't typically go nearly that fast. The Rover has to spend a lot of time assessing the safety of the terrain. It has a set of cameras that it will use to build up a three-dimensional range map of the topography in front of it and figure out what it is safe to go over and what it has to go around. You can actually program different levels of courage or cowardice into the vehicle, depending on how scary you think the terrain is. Our all-time record was 220 meters in one day. In comparison, the *Sojourner* Rover on Mars Pathfinder did, I think, 106 meters over its entire lifetime. So 220 meters in a day is pretty good. Our all-time record for *Spirit* is 125 meters in a day. In good terrain a typical number is 20 or 30 meters in a day. For *Spirit* these days, with that busted wheel, 5 meters is a good day.

Question: I'm under the impression that it's pretty cold on Mars. I wonder if you saw any evidence that the water ever froze. Were there places where you might have expected it to freeze and you saw something different?

Squyres: We've thought a lot about that, and I think our data do not enable us to answer that question. Features that we've seen, including those little ripples that speak of surface water, could form perfectly well under an ice cover. Water can flow under a cover of ice; I see that in Ithaca, New York, in the winter. So I don't think that our mission has really addressed that. I have not seen anything that is uniquely attributable to ice, nor have I seen anything that I think rules it out.

Question: How confident can you be that your extrapolations from what you've seen in this tiny surface would be true elsewhere?

Steven Squyres: I worry about that one a lot. I feel pretty confident about our interpretations at these two little pinpricks on the surface of Mars. However, the combined surface area of Mars is equal to the combined surface area of all the continents of Earth together. *Spirit* has gone 7.5 kilometers; *Opportunity* has gone 12 – there's a lot of Mars we haven't seen. Mars is incredibly diverse geologically. We know that from images that we see from orbit – just look at how different our two landing sites are, for example. It would be reckless to try to extrapolate too far from these two little spots on the surface. We are trying to characterize these two places and then interpolate as best we can using orbital data. But if you put a dozen of these Rovers down on a dozen places on Mars you'd get a dozen different stories; that's the nature of the business. ■

Margaret Geller (Harvard-Smithsonian Center for Astrophysics) and Scott Kenyon (Harvard-Smithsonian Center for Astrophysics)

Elaine Musgrave (Wiley-Blackwell Publishing) and Michael Wood-Vasey (Harvard-Smithsonian Center for Astrophysics)

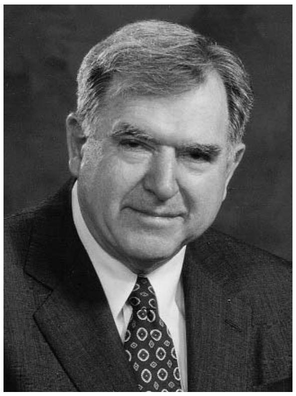
Linda Gelb, Arthur Gelb (Four Sigma Corporation), and Leslie Berlowitz

Book Hours on Health and Medicine

A Second Opinion: Rescuing America's Health Care

Arnold S. Relman

This presentation was given at the House of the Academy on November 29, 2007.



Arnold S. Relman

Arnold S. Relman is Professor Emeritus of Medicine and of Social Medicine at Harvard Medical School and former Editor-in-Chief of the New England Journal of Medicine. *He has been a Fellow of the American Academy of Arts and Sciences since 1965.*

It's an honor to have this chance to discuss the health care situation with friends and colleagues here at the Academy.

In 1977, soon after assuming the editorship of the *New England Journal of Medicine*, I became aware that investor-owned companies were beginning to reshape the U.S. medical care system. Attracted by the opportunities for profit afforded by the cost-plus reimbursement policies of employment-based private insurance plans and of Medicare, chains of for-profit hospitals and ambulatory facilities of all kinds suddenly appeared on the scene. They started to change the health care system from the essentially not-for-profit social service that it was when I started out in medicine just after World War II to an industry focused primarily on generating income for investors, managers, and physicians.

In 1980 I first called attention to this development in an article in the *New England Journal of Medicine* entitled "The New Medical Industrial Complex." I wrote that this new investor-owned medical care industry threatened to shift the fundamental orientation of our health care system. It was also causing the not-for-profit sector of health care to behave as if it, too, were investor-owned, because it had to compete with investor-owned hospitals for income and market share.

The commercialization of medical care institutions was also changing the behavior of physicians – attracting them into all sorts of financial arrangements with the corporate providers of care and the manufacturers of drugs and medical devices. Physicians control the use of most medical resources and are paid primarily on a fee-for-service basis. There was a real possibility that they would let their own financial interests transcend their commitments to patients. Of course, it has to be acknowledged that physicians have always been concerned about their income and some, over the years, have been much too concerned. But the appearance of investor-owned medical care institutions had begun to weaken the traditional wall between business and the professional practice of medicine. In my view, this did not bode well for the future of our health care system because it would drive up costs, threaten the quality and accessibility of medical services, and undermine patients' trust in their doctors.

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The reaction to that first article surprised me. Although my account of the historical facts was never seriously challenged, few experts shared my concerns about their implications. Most health economists saw, in the rise of investor-owned care, nothing more than a rational response to changing market incentives. Most other social scientists totally ignored the threatening implications of investor-ownership in health care and saw the rapid growth in costs and provider income simply as further evidence of the domination of the health care system by doctors and hospitals, which they had been decrying for years.

In December 1985, at the 1664th Stated Meeting of this Academy, I took another look at the growing influence of commercialization on our medical services in a talk entitled "What is Happening to our Health Care System?" Despite efforts to contain costs in both the public and the private sectors, by 1985, the fraction of the economy devoted to health care had risen fairly steadily from about 6 percent in 1966, the time when Medicare first appeared, to about 11 percent in 1985. All signs pointed to a continuing rise in costs that would exact a heavy toll from the federal budget allocated to Medicare and from the business employers who were paying most of the health care insurance premiums of their workers. By then, about one in four non-public general hospitals, most private psychiatric hospitals, and the majority of private insurance plans had become investor-owned businesses. Meanwhile, investor-owned ambulatory care facilities had continued to multiply. I estimated, at that time, that about 20 – 25 percent of all expenditures on personal medical care were going to investor-owned businesses, and this fraction was increasing rapidly.

There were no hard data, but a number of other people who were looking at the growth of the investor-owned sector in health care came to the same conclusion. Meanwhile, there was no doubt that rising costs were limiting the access of the poor to medical care. At the Academy meeting in 1985, I predicted that within a few more years, or perhaps a decade, there would be an inevitable political backlash against this inequity that would result in some sort of national health insurance system as a means of controlling costs, ensuring quality, and providing access to health care for all.

Well, that was almost twenty-two years ago, and we're still waiting for the political backlash I had predicted. Meanwhile, the investor-owned sector has continued to grow along with the cost and inequity that I thought would soon generate a movement for major health reform. I suppose that I could claim at least some vindication because about eight years later, in 1993, the new Clinton adminis-

Failure to provide health insurance coverage for all is sometimes seen as our most important problem, but high costs are really at the heart of the U.S. dilemma.

tration introduced a bill to extend coverage to almost everybody and to control costs. The plan was based on what was then called "regulated competition" among managed-care insurance plans. It was a kind of political backlash, but it never even got out of Congressional committee and within a year was killed by opposition from the investor-owned health care and health insurance industries, by conservatives in Congress, and by resistance from the American Medical Association.

For a few years after that, health costs were held in check by a strong HMO insurance industry, which forced primary care physicians to limit referrals to specialists, constrained expensive testing and elective admissions to hospitals, and discounted payments to all providers. But growing resistance to these constraints from patients, physicians, and the media soon brought a return to insurance plans that allowed more freedom of choice. By the end of the 1990s, HMOs were fading. Health costs had resumed their climb, and it was apparent that neither existing market forces, nor any politically acceptable legislative reform would resolve our health care problems any time soon.

It was then that I decided to begin work on a book summarizing my own view of what was wrong with the system, and how it should be reformed. Despite the multitude of publications on the subject, I was persuaded that few of them saw the problem in its full perspective or offered a workable comprehensive solution. I was also aware that studies of the health care system were usually written by economists, social scientists, or business experts, and that their ideas are shaped more by their own disciplines than by familiarity with medical care as it exists in real life. Practicing physicians, with few exceptions, have not been inclined to write books about the health care system. It seemed to me that first-hand familiarity with the practice of medicine and with medical institutions should be of considerable help in thinking about health reform, and that my experience might produce a book quite different from most of those written by non-physician health care experts. I could claim no special wisdom, but had been fortunate enough to study U.S. medicine up close for many years while it was being converted to an industry. Indeed, I was personally involved in many of the events surrounding that transformation.

So I undertook this book with the hope that it would help readers to take a fresh look at what was happening to our health care system. That is what the book's title, *A Second Opinion*, is intended to suggest. It's short – only about 200 pages – and it's addressed to lay readers and written in simple nontechnical language. It's a primer intended to clarify matters that have far too often been obfuscated by the experts. In my view, the issues are not really that complicated, the essential facts not that numerous or mystifying, and the options for a real solution relatively easy to sort out.

The book begins with an introduction in which I say, "Failure to provide health insurance coverage for all is sometimes seen as our most important problem, but high costs are really at the heart of the U.S. dilemma." I suggest that what makes U.S. health care so expensive is the extent to which the insurance and delivery of our medical care is governed by commerce and private enterprise, rather than by public regulation and social need. To deal with that problem, and to develop a health care system that covers everybody and provides good quality care at a cost we can afford, we must change not only our system of insuring and paying for health care, but also the way we organize and deliver that care. The rest of the book is a development of those themes.

We must change not only our system of insuring and paying for health care, but also the way we organize and deliver that care.

Commercialization of U.S. Medicine

Our health care system has changed from the modest sized, low-tech social service it was when I graduated from medical school in 1946 to the vast, high-tech service industry it is today. The two primary agents of that change were, first, the post–World War II explosive growth in medical science, technology, and education; and second, the rapid influx of huge sums of money from private and public insurance plans. Eli Ginzberg, the late brilliant health economist at Columbia University, described this as "the monetization of health care." He said it was the necessary antecedent to the commercialization of health care, and he was right. Cost-plus insurance payments attracted investor-owned businesses that exploited the many opportunities for profit in the new specialties and the technical procedures that characterized the postwar explosion in medical science.

The law also weighed in on the side of commercialization when, in 1975, the Supreme Court ruled that the learned professions were not automatically protected from anti-trust law. In effect, the Court held that, at least under some circumstances, medical practice should be viewed by the law as a form of interstate commerce, and therefore subject to anti-trust regulation. In my opinion, this issue still awaits further legal clarification. Those with a legal bent should read Chief Justice Warren Burger's oft-quoted footnote 17 to the opinion he wrote in the 1975 Virginia Bar Association case. He said he wasn't sure how far this concept could be extended to the practice of medicine; he said he was applying it only to the facts of this case. Although Burger didn't say it, the implication was that the Court would have to think more about this. Well, they haven't. A number of anti-trust cases were instituted against medical organizations, including the AMA, and were settled in lower courts, and there has been no opportunity for the Supreme Court to revisit the issue. When the medical organizations lost all of these cases, the AMA rapidly retreated from its former ethical stand about medicine not being a business and doctors not making money from business ventures and said, in its guidelines starting in 1980, that medicine is both a business and a profession. Now the AMA says that it's acceptable for doctors to make money by investing in businesses and in the products that they prescribe so long as they disclose this to their patients and so long as it doesn't harm the patients. That's a sad state of affairs for those who, like me, believe such behavior undermines the professional values of medicine.

We now spend well over $2 trillion a year, more than 16 percent of our total economy, on health care, and expenditures have been rising at more than twice the growth rate of our economy.

In comparing the U.S. health care system with health care systems in other advanced countries, I noted that although most of these countries experienced the same developments in medical science and technology we did, they had, to varying degrees, universal, publicly regulated health insurance plans already in place. Public regulation in other countries has prevented private enterprise from securing more than a marginal position in their health systems. Only recently have the rising costs of health care and the sales pitch of an increasingly globalized medical-industrial complex tempted other countries to follow us down the garden path of commercialization. So now you have developed countries like Sweden, Canada, and the United Kingdom and relatively undeveloped countries like India asking, what can privatization do for us? The answer, as the next chapter of the book demonstrates, is "nothing of social or economic value to the community – only the enrichment of the privatizers."

Consequences of Commercialized Health Care in the United States

Rapidly rising costs are the central problem. We now spend well over $2 trillion a year, more than 16 percent of our total economy, on health care, and expenditures have been rising at more than twice the growth rate of our economy. It's clear that we cannot sustain this trend much longer. I estimate that at the present time, somewhere between 40 percent and 50 percent of all health care related expenditures are being paid to investor-owned facilities and investor-owned organizations. The Congressional Budget Office recently declared that the growth of Medicare costs is the most serious threat to the integrity of the federal budget. Business employers are also warning that although they want to help with their employees' health insurance costs, they cannot continue to do so at anything near present levels without endangering the survival of their businesses. General Motors is a case in point; its CEO says that its growing health costs simply cannot be sustained.

Rising costs make health insurance less affordable, so there are now nearly 48,000,000 citizens without insurance, and probably at least half again as many who are underinsured. The lead headline story in today's *Wall Street Journal* is about how hospital costs bankrupted a well-insured but seriously ill employee whose insurance simply ran out when the hospital bill rose to $2,000,000. How much of the rising cost of health care can be attributed to factors other than commercialization – the aging of the population, the increase in the prevalence of chronic illness, the moral hazard of low-deductible insurance, fee-for-service payments to physicians, and the proliferation of expensive new technology – is a legitimate question. However, we do know that in many other advanced countries, these same factors exist to varying degrees, although health expenditures in these countries have been much lower than ours. The unique difference between our health care system and those of these other countries is that theirs is more organized and regulated by government, while ours is more driven by market forces and much more commercialized.

The unique difference between our health care system and those of other countries is that theirs is more organized and regulated by government, while ours is more driven by market forces and much more commercialized.

That commercialization plays an important role in U.S. health care costs is also suggested by our knowledge of how businesses work. Investor-owned health care businesses, like any other businesses, seek to reward their investors by increasing the value of their stock. That's basic. To do that, they must drive up their net income. Investor-owned health care institutions usually have higher overhead costs than public or private not-for-profit institutions. To generate higher income, investor-owned institutions must either sell more services or price them higher, or curtail expenses. There is no evidence to support the claim often made by advocates of for-profit health services that such services are lower-priced or of higher quality. To the contrary, the limited number of well-controlled, head-to-head comparisons between investor-owned and not-for-profit facilities tends to show either no significant difference in price and quality or, more often, differences favoring the not-for-profit sector.

The Revolt of the Payers

The history of attempts by government and by private payers to control health care costs goes back to the Nixon administration when the private HMO movement began. HMOs reached their high point in the 1990s following the defeat of the Clinton "managed competition" plan, and for a short time, they succeeded in restraining the cost of private insurance. But their success depended on limiting the choices afforded to doctors and patients, and they soon lost popular support. In the public sector, Medicare tried to control its costs by folding piecework payments to hospitals into single DRG (diagnosis-related groups) payments for each category of clinical problem. Later, it tried to control payments to doctors by establishing standard fee schedules according to the complexity or intensity of the services.

Both approaches had some effect in controlling costs, but not much and not for long. The reason is obvious: even when fees are bundled or fixed, the number and choice of services remain largely under the control of physicians. In a system dominated by entrepreneurial incentives and investor-owned enterprises, physicians and health care facilities will continue to maximize their income by providing more of the services that are profitable. Medicare is an example of a low-overhead, single-payer system, and its failure to contain costs (its costs are rising almost as rapidly as in the private sector) is powerful evidence that cost control will require a change in the care delivery side of our health system as well as in the insurance side.

Other proposals for cost control are being considered, but in my view, they are unlikely to work. Explicit government rationing of the use of expensive technology won't work in this country because there is no effective and politically acceptable way to make and implement such rationing decisions. Lowering expectations for treating the very old with expensive technology of marginal value has been suggested as a way to control costs. It may be a good idea, but it's unworkable because it is, in effect, rationing based on age and is not politically acceptable. Another proposed solution for the cost crisis is through continued advances in medical science that will ultimately eliminate chronic diseases. But none of us will live long enough to see this happen, even assuming it would have the desired effect. And finally, reform of the malpractice litigation system, a cost-controlling policy particularly favored by the AMA, would have only a relatively small effect on national health expenditures. Although the litigation system certainly needs reform, its costs are a minor fraction of our current health costs.

Consumer-Driven Health Care

The latest and most popular proposal for controlling costs is so-called Consumer-Driven Health Care (CDHC). In some version or another, it underlies almost all the health policies of those who believe that free markets can solve our health problems, including the Bush administration, conservative think tanks, and many economists and business people. They argue that the best way to curb spending is to have people pay more of the cost and take more of a role in choosing their own care. The three pillars of CDHC are a high-deductible "catastrophic" insurance plan, a tax-free "health savings account" to help pay the costs of medical services, and more information for consumers, including physicians' fees and technical information about available treatments and their outcomes.

> *If we had a really efficient system – eliminating business overhead, profits, ineffective and unnecessary services, and billing fraud – we could probably spend 35 – 40 percent less to cover the same population we do now.*

What's wrong with the CDHC idea? It is, first of all, unfair because it will inevitably have the greatest impact on health services for the poor. Secondly, it is based on the fallacious notion that sick patients can, and should, choose their own care as if the health care system were just like an ordinary market. In addition, CDHC does not address the factors in the delivery systems that are responsible for high and constantly rising costs; it also fragments insurance pools and loses the collective benefits of insurance; and it makes integrated, electronic medical record keeping almost impossible. Despite these fatal flaws, CDHC will probably have to play itself out for a few years, before it is finally abandoned.

The Reform We Need

Now, I would like to propose my own solution for our ailing health care system. As a former medical educator and clinical consultant in internal medicine, I taught students and house officers that effective treatment of the patient must begin with an accurate assessment of the problem. If you don't know what's wrong, your treatment is not likely to be very helpful. So here we have a desperately sick health care system. If my diagnosis is correct, then the treatment should be aimed at remedying the system's problems that I've already described. There are two parts to my proposal.

Collective Funding and a Single Payer

First, expenditures must be controlled, and the most effective method for doing that is to set a national budget. We currently spend more than $7,000 per U.S. citizen on health care. Spent properly, this amount is more than enough to meet everyone's needs for all necessary care, acute and chronic. The U.S. problem is not lack of money. We're spending over $2 trillion, and if we had a really efficient system – eliminating business overhead, profits, ineffective and unnecessary services, and billing fraud – we could probably spend 35 – 40 percent less to cover the same population we do now. These savings would pay for the cost of covering everyone and probably leave enough to improve the system in many other ways. The savings would pay for new health promotion programs and support medical education and research. The budget would be funded from all the present sources, public and private, that now pay for health care. These sources could ultimately be bundled together and paid into a universal, earmarked, and progressive health care tax.

Earmarking that money would be important to avoid conflicts and confusion with other tax revenues. The Canadians have that problem. Their health care expenditures are mixed together with all other social expenditures;

there is also a financial tug-of-war between the central government and each provincial government, which leaves the provinces struggling to find enough to provide good health care. Canada needs to spend more tax money to keep its excellent public insurance system viable. The segregation of health care money in the United States would be facilitated if health care were managed by a designated public/private agency, comparable to the SEC or the Federal Reserve. This agency would spend most of its budget on per capita reimbursement of the medical groups that would provide care for all those in the plan. If the agency were also responsible for paying the hospitals and other health care facilities, its reimbursement of the medical groups

Even if our next president were to favor major reform, opposition from vested interests in the private insurance, investor-owned health care, and pharmaceutical industries, coupled with strong resistance from market ideologues, would be too much to overcome right now.

would be accordingly reduced, but I am presently inclined to believe that the capitated payment to the groups should include what the groups would pay the facilities for the institutional care of their patients. In any case, there would be no billing or collection transactions involving physicians' services, which would result in great savings.

Most important, central funding by the health agency would replace the multiple private insurance plans whose profits and overhead now exact such a heavy toll from payers. There is simply no evidence that these investor-owned insurers provide services remotely worth the huge sums they take out of insurance premiums before paying health care providers. The private, for-profit health insurance industry, which is a relatively new arrival on the scene, began to expand just a couple of decades ago. They are, in my view, little more than middlemen in our health care system, and we would be much better off without them. Nevertheless, they will fight to maintain their position.

Reorganized, Nonprofit Delivery System

I stand with those who believe that a universal not-for-profit, single-payer should replace the private, for-profit insurance industry. But unlike most single-payer advocates, I do not believe that this reform will stem the rising costs of health care. As I've said, Medicare is a single-payer, and its burgeoning expenses prove my point. That is why my proposal also includes a reorganized delivery system based on nonprofit medical care institutions as well as prepaid, multi-specialty nonprofit group practices and salaried physicians. In every community, there would be an appropriate number of modest-sized, not-for-profit, prepaid, multi-specialty group practices that would, in effect, be small versions of group practices that now exist, such as the Mayo and Lahey Clinics. Patients could choose any group in their community and select any primary care physician in the group to manage their care. Groups would employ an approximately equal number of primary care physicians and specialists who would collaborate with each other and with other health care personnel in the group to provide appropriate and accountable care. Electronic records could become universally adopted by these groups, and technology assessment would be facilitated. Perverse economic incentives would be eliminated, because the groups would be nonprofit and would be protected by the central payer against any financial loss due to adverse selection by seriously and chronically ill patients. Groups would not be allowed to select their members, so anyone, regardless of medical condition, would be free to join a group so long as its capacity allowed for new members. These groups would be nonprofit institutions that did not have to worry about their bottom line, as all multi-specialty groups now must do.

All physicians would be salaried by their groups and the total physician share of each group's income would be limited to the approximate percentage of health expenditures currently received by U.S. doctors. Patients and physicians could choose between being

Within about five years, or at most a decade, we will be forced to abandon the present commercial health market in favor of a more socially oriented system.

fully in or out of the universal health plan; however, everyone would still pay the health care tax just as everyone now pays local property taxes that support public schools, even if they send their children to private school. Private health insurance would be permitted to cover only services that are not provided under the universal plan; these would be determined by the central health agency. The agency would not have to decide what services were provided under the health plan, but only what wouldn't be paid for. The physicians and the patients in each group would decide in each case what should be done, based on individual circumstance, patient preferences, and the best available medical evidence. The basic idea behind such groups would be to compensate physicians for their time and effort in providing optimal care for patients, without the perverse incentives inherent in a fee-for-service system.

Can We Get There?

Finally, I come to the question of whether such reform is feasible or just wishful thinking. I know that a major restructuring of the system would undoubtedly be a formidable task that is not likely to occur in the short run. Even if our next president were to favor major reform, opposition from vested interests in the private insurance, investor-owned health care, and pharmaceutical industries, coupled with strong resistance from market ideologues, would be too much to overcome right now. So I do not expect to see any major change in health care soon after the next election. In the long run, however, major reform is inevitable, although it may well be accomplished by step-wise legislation.

Sooner or later, business leaders in the non-health care sector of our economy will have had enough. Many of them have already said that health costs must be contained through reform of the system. Opinion polls show that the growing army of U.S. citizens who are being financially threatened by rising health costs or are facing the terrifying prospect of major illness without insurance protection are coming to the same conclusion. And so will legislators who will begin to realize that rising health costs are destabilizing government budgets and preventing expenditures on other essential national needs. Legislators will also realize that they need votes and popular support even more than the financial support of the interests vested in health care.

Another reason I believe major reform is inevitable is that the attitude of the medical profession is changing. Heretofore steadfastly opposed to fundamental change in the health care system, physicians are now beginning to reconsider their position. A bare, but growing majority now believes that major reform is necessary, although the AMA has yet to change its traditional conservative position. Women will soon represent nearly half of all practicing physicians, and there is reason to believe most of them would be comfortable with a reformed delivery system based on group practice. But all physicians are coming to realize that present trends are compromising their professional independence and integrity. Without major reform, economic imperatives will continue to undermine professional values and eventually change medical practice into little more than a highly technical, highly paid business. This would not be in the public interest, nor would physicians like such a development.

In the last chapter of my book, I urge physicians to participate in developing a workable reformed system. The handwriting is on the wall, but it may take some time for our nation to realize that market-driven health care is not the solution. Within about five years, or at most a decade, we will be forced to abandon the present commercial health market in favor of a more socially oriented system. This time major health reform will not be denied. ■

Book Hours on Health and Medicine

The Cancer Treatment Revolution: How Smart Drugs and Other New Therapies are Renewing Our Hope and Changing the Face of Medicine

David G. Nathan
Introduction by Mitchell T. Rabkin

This presentation was given at the House of the Academy on February 28, 2008.

Mitchell T. Rabkin

Mitchell T. Rabkin is Distinguished Institute Scholar at the Shapiro Institute and Professor of Medicine at Harvard Medical School. He has been a Fellow of the American Academy of Arts and Sciences since 1998.

Introduction

The expectation for graduates of Harvard Medical School is one of success. Many become known for excellence in clinical medicine, research, or teaching. A few become quite distinguished, but it is the rare individual, such as my classmate, Dr. David G. Nathan, who warrant such recognition in all three areas, and add successful careers in academic management as well.

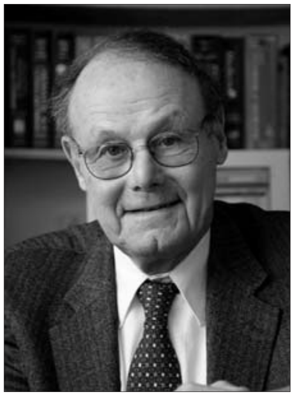
After residency in medicine at Peter Bent Brigham Hospital and two years at the National Institutes of Health in the National Cancer Institute, David focused his career on hematology, and particularly genetic disorders of blood cells. This drew him from the Brigham to Boston's Children's Hospital, where he headed its Division of Hematology and then the Combined Division of Pediatric Hematology and Oncology at Children's and the Dana-Farber Cancer Institute. The excellence of his work led to membership in the Institute of Medicine of the National Academies, the American Academy of Arts and Sciences, the American Philosophical Society, and many other selective organizations in academic medicine.

From 1985 to 1995 he served as Physician-in-Chief at Children's Hospital, continuing his laboratory research as well, and then headed the Dana-Farber Cancer Institute for five years, expanding its purview through development of the Dana-Farber/Harvard Cancer Center involving all the major affiliated hospitals.

He has authored over 350 papers, a leading textbook of pediatric hematology and oncology, and two books for the general reader – *Genes, Blood and Courage: A Boy Called Immortal Sword* in 1995, and tonight's subject, *The Cancer Treatment Revolution: How Smart Drugs and Other New Therapies Are Renewing Our Hope and Changing the Face of Medicine*.

Even with his distinguished career and many accolades and accomplishments too numerous to mention, he retains the modesty and good humor I noted during our years together as students. Perhaps those characteristics are reinforced by Amazon's report of tonight's book as listing at $24.95, available new at $19.96, and in the category of "used," starting at 14 cents! I've read it and know it is worth a great deal more.

Please join in welcoming Harvard's Robert A. Stranahan Distinguished Professor of Pediatrics and Professor of Medicine, my colleague and friend, Dr. David G. Nathan.



David G. Nathan

David G. Nathan is Robert A. Stranahan Distinguished Professor of Pediatrics and Professor of Medicine at Harvard Medical School and President Emeritus of the Dana-Farber Cancer Institute. He has been a Fellow of the American Academy of Arts and Sciences since 1983.

Presentation

At least I didn't burst out laughing until the end. I try to control myself when Mitch is around, but I start laughing as soon as I see him. He is the funniest man I have ever known in my career and a dear friend, so I appreciate the introduction enormously. Before I start, I want to welcome all of you because many of you are my close friends in science and medicine, and I am very grateful that you are here.

Tribute to Judah Folkman

I am particularly grateful to Paula Folkman for joining us this evening. We've had a terrible loss in the death of Judah. I knew Judah when he came to Children's Hospital in the 1960s. He began his independent career at Harvard in the bottom of the Sears building of the old Boston City Hospital. I knew about him from Sydney Farber, who told me when I first came to Children's Hospital, "Dr. Nathan, you are going to meet the most brilliant man I have ever met," and that was Judah Folkman. It was Farber who was largely responsible for Judah's appointment to replace the great Robert Gross, Surgeon-in-Chief at the Children's Hospital and, in many ways, one of the inventors of pediatric surgery – an absolutely brilliant technical surgeon. Gross saw something very special in Judah when Judah was just an undergraduate at Ohio State and then a medical student at Harvard.

Judah went to the Massachusetts General Hospital (MGH) as an intern, at a time when it was really the soul of Harvard surgery. I was a Brigham intern, but I can tell you that MGH was the place to go for surgical training at that time, and it is still a great place for surgery. Judah was a brilliant house officer and chief resident at MGH. Then one of its former faculty, Bill McDermott, went over to the City Hospital to run the Harvard service there. McDermott brought Judah with him. In that grotto of a laboratory, Judah discovered that there was something very special about blood, and particularly blood platelets that had a specific effect on the way blood vessels grow. Many years later, it turned out that platelets contain a growth factor that they suck up into their granules and lay down on the blood vessel surface, making the blood vessels proliferate. That was Judah's first major discovery at Harvard.

We know that the coming cancer treatment revolution will be based entirely on the genetics.

In that old Sears lab, Judah worked with some of the most brilliant people in Harvard medicine. When I met him, I was bowled over. All I could say to Dr. Farber was "You're right. He's extraordinary." When Judah was teaching, rounds at the Children's Hospital resembled Park Street Under. You couldn't get near the man. He was surrounded by students and residents, and not just surgical residents but medical residents and pathology residents; everybody wanted to hear what he had to say. There was a reason for that. He had insight. Lots of people dutifully do the work, but they don't observe; they just do. The literature is filled with "do." To make advances in science, one must keep looking and thinking about what one is doing and noticing something that is different, something unexpected. That is what great science is all about, and that is what Judah could do. I didn't always agree with him. My goodness, we had plenty of disagreements about the way cancer works and about how to go after it. But at no time have I ever seen anybody with that kind of insight and joy in science. He loved it and he loved people in science. He loved to talk about science, anybody's science.

Cancer is a disorder of the chromosomes, and therefore a disease of the genes. It is the result of an abnormal amount or function of specialized proteins that influence cell growth.

I went to him several times when I got discouraged about what I was doing and he would always say, "Well, just keep looking. It will work out fine. Just don't take your eyes off it." He was a great physician scientist, and Harvard will miss him desperately. Children's Hospital will never replace him. He will never happen again; he was just a one-time miracle. Whether Paula was here or not, I wanted to take this opportunity to talk about him because there are great people in academic medicine and then there are the greatest ones: one of those was Judah Folkman.

The Nature of Cancer

In Judah's honor, I would like to talk about the revolution in cancer treatment because he was so much a part of it and the new thinking. As Mitch said, my interest was in working on the genetic basis of blood diseases, not realizing at the time that cancer is by far the best model for genetic disease. Cancer is for the most part an acquired genetic disease, but we didn't appreciate that very much when I began my work in the mid-1950s. Now we all know that the coming cancer treatment revolution will be based entirely on the genetics.

Before I launch into the role of cancer genetics, I want to say a bit about the cancer problem. In America alone, over a million new cases of invasive cancer and half a million deaths occur every year. It is an enormous public health issue in this country, and it is a huge and staggering problem around the world. In the United States, we spend $200 billion a year in the care and lost productivity associated with cancer. So cancer, as a target, is extremely important.

The 1950s ushered in the era of the biological basis of medicine. After my internship in 1955, I had a chance to go to the National Cancer Institute just as the NIH clinical center was opening and clinical research on patients with cancer was starting. I have been watching cancer treatment very closely ever since, and I have an objective view of these developments because I wasn't at the center of the research. My own interests moved me into the field of inherited blood diseases.

As I considered my book, *The Cancer Treatment Revolution*, I knew that I would never be able to reach the general public if I just recited facts. Instead, I decided to tell the story of three patients: a child with leukemia, who I called Mario; a woman with breast cancer named Joan; and a man called Ken who had a very unusual bowel cancer. The book is all about them, and through them the book tries to teach what has happened in the last half century to change cancer treatment.

Before I tell these stories, I would like to discuss what cancer really is. Cancer is a disorder of the chromosomes, and therefore a disease of the genes. It is the result of an abnormal amount or function of specialized proteins that influence cell growth. There are three major types of cancer, and they are very different.

First, let me consider the common cancers, the so-called *epithelial cancers* that kill a lot of people. Humans are basically a bunch of tubes, surrounded by muscle, bone, and skin. The gastrointestinal track, the lung and the airway, and the urinary tracts are all tubes, and the liver ends up pumping its stuff out through tubes. The lining cells that make those tubes function are called epithelial cells, and they turn over quite quickly. They are sloughed through the tubes, which can be thought of as rusty pipes. Just as rust trickles off pipes into the water, the epithelial cells drop into the liquid or the air passing through the tubes, and they eventually die. They are replaced by stem cells that grow in little sections of these tubes and become new epithelial cells.

A lot of cell division goes on in these tubes, and that becomes important because cell division creates a change in the chromosomes of cells. When a cell divides, the chromosomes and the genes they bear open up, and when they open, the genes become highly susceptible to toxins that are sitting around waiting to attack and mutate or change them. The acts of cell division and attack by toxins are random events. For example, a gastrointestinal epithelial cell lives in the midst of a lot of germs that are trying to have a life for themselves. The germs extrude products of their own metabolism and some of these are toxins. So there is a chance that a gastrointestinal epithelial cell will get hit by the product of a bacterium that is just sitting in the colon, and it may be hit enough to become a cancer cell.

The best treatment for cancer is surgery – there is no question about that. If a tumor is really localized, then the surgeon can cure cancer.

The cancer occurs if one or more of the random mutations in an epithelial cell cause the cell to divide continuously. The mutations can also damage the very elaborate mechanism that these cells require in order to repair themselves. There is also a whole detection system in epithelial cells that tells them that the cell is damaged. The cell responds by committing suicide. Sometimes a mutation occurs right in the very genes that commit the suicide. Such a mutation makes the cancer cell immortal.

So cancer can arise for three reasons. First, there may be damage to genes that may make cells proliferate much faster; second, there may be damage to the genes that repair them; and third, there may be damage to the system that makes them die. That latter point was discovered by the late Stanley Korsmeyer. Many cancer cells have mutations in all three systems.

A brief explanation of the two other forms of cancer is necessary because all three will be part of this discussion. In addition to the epithelial cells of the tubes, there are the disorders of the bone marrow and the lymphatic system: they are the *leukemias and lymphomas*. Fortunately they are quite rare and occur predominantly in children. About 30 – 40 percent of cancer in children is represented by leukemia and lymphoma. And there are still rarer cancers, again more common in children, called *sarcomas*; they are the cancers that arise in the structural parts of the body. As I said, we are tubes, but we have to support the tubes with muscle, bone, nerve, and even a brain. The tumors that involve those supporting structures are called sarcomas. The leukemias, lymphomas, and sarcomas are rare, but the epithelial cancers are very common and include breast, prostate, lung, and gastrointestinal cancer. These are the cancers that really matter economically.

As pediatricians, we emphasize cancer in children but there are only 3,000 – 4,000 new cases of childhood leukemia per year in the entire United States and leukemia represents 30 – 40 percent of all cancer in children. The rest are almost all sarcomas. Obviously the epithelial cancers that affect adults are the major public health issue.

Since damage to epithelial cells is cumulative, the longer you live, the higher the chances are that ultimately you will get cancer. If you watch epithelial cancer's age-specific incidence, the curve is quite flat and low until people are around 30 or 40 years old. At about 40, the curve begins to break and start up. By age 60, it is going up rapidly and by age 80, the rate is enormous. This is not a trivial problem, and it suggests evolution that never intended us to be around much beyond age 45. The purpose of evolution is to create an organism that can eat and procreate in a given environment. We are not destined to be cancer free. As an older population, that is our plight – and we are going to get older because the cardiologists have done such a good job. Talk that cancer can be prevented is close to pie in the sky. Only removal of tobacco and exogenous estrogen and reduction of sun exposure can make a significant difference. Tobacco, which is by far the biggest mutagen of all, is critical. If we got rid of tobacco, 30 percent of all cancer would disappear. There is no other factor, other than estrogen for women, that has an effect like that of tobacco. My friends at the School of Public Health sometimes get mad at me because they are so into diet, but when you compare diet to the mutations that are going on naturally in the body, it is nearly meaningless. We are constantly being attacked by germs that we can't get rid of and by the oxygen radicals that we metabolize ourselves. There are some environmental issues that we could work on, such as asbestos, a tumor-causing agent often found in shipyards. In the end, however, it is extremely difficult to prevent cancer unless one reduces tobacco use, excess sunlight, and estrogen intake.

What about screening? The best treatment for cancer is surgery – there is no question about that. If a tumor is really localized, then the surgeon can cure cancer; even today, most cures are surgical cures. If it weren't for the fact that surgeons can cure people, we would not be screening people. But here is the problem with screening: It is not that I'm against screening, but 80-year-old men – and I'm going to be 80 in a year – have an enormous incidence of prostate cancer, probably 80 percent of them have little nodules of prostate cancer. In most of them, it doesn't go anywhere. Their prostate-specific antigen, or PSA test, may be up, but the cancer isn't important. In fact, I believe we are making tumors in us all the time due to these mutations and they are going to go away or never get anywhere. A very sensitive screening system will find such a tumor. The surgeon will take it out and say "I cured you." But the mortality doesn't change. Even if we screen and screen and take out early tumors, the death rate changes very little. Why? Because we remove so many tumors that weren't going to kill anyway. They are going to die on their own. That is the problem with screening.

H. Gilbert Welch of Dartmouth has written a book about this, and he's right. The problem is what does my poor doctor do if it's my PSA? He begins to get nervous and says, "I can't let Nathan be an experimental subject. I've got to do something. If I lose Nathan, look what could happen." I can hear it all.

I would never prevent my wife from having a mammogram. That would be outrageous, but I believe that mammograms do not prevent cancer deaths very much. Maybe we get about 11 percent improvement in life span. In the end, if we are going to screen, let's screen a population that is really susceptible, specifically African Americans. They have vicious prostate cancer and terrible breast cancer. We don't know why. It has nothing to do, in my opinion, with economic class because Eskimo Americans and American Indians, who are just as poor, don't have anything like that kind of severe cancer. It appears to be genetic but our information is not thorough enough to be definitive. My view may be controversial, but I believe we should focus much of our screening effort on those who are most susceptible.

Cancer can arise for three reasons. First, there may be damage to genes that may make cells proliferate much faster; second, there may be damage to the genes that repair them; and third, there may be damage to the system that makes them die.

The leukemias and the sarcomas begin their cancerous existence more simply than the epithelial cancers. The cells of an epithelial cancer look as though a bomb went off in the nucleus. The chromosomes are totally smashed. The fact that we can't kill them is really a blot on us because these are rotten cells. We try to kill them with chemotherapy, but they can have mutations that make them resistant to chemotherapy. They are constantly mutating right in front of our eyes; as soon as we find a drug for them, they become resistant to it because they mutate again and again and develop a new kind of gene that blocks the effect of the drug. Even though they are terribly weak compared to normal cells, it is their rottenness that makes them very difficult to kill.

The leukemias start out much simpler. Two chromosomes in one cell cross each other in an abnormal way and produce an activated gene. That one gene then turns on some other genes and creates a problem in cell development. This is a lot easier to treat with common drugs, and that is reflected in our modern success with childhood leukemia. When I went to the National Cancer Institute I took care of about 30 kids with leukemia, and I didn't have a single survivor. That was 1956 and today the survival rate is 85 percent. We are even getting on top of the pediatric sarcomas.

The cancer treatment revolution dates back to 1974 when two experiments were done, the first carried out by Robert Weinberg at the Massachusetts Institute of Technology. He was interested in bladder cancer, and asked, "Why does bladder cancer, an epithelial cancer, occur?" He discovered that there is a gene that regulates cell growth in bladder cells. That gene is often mutated in bladder cancer. The gene may bear a single mutation, affecting one amino acid. Proteins are made of amino acids and, in this particular protein, there are 174 amino acids: one of them was wrong. One amino acid drives the whole cancer. At the time, I didn't know much about cancer, and I thought this was incredible; I thought we should be able to cure that. It was the opening gun for me. Then Philip Leder at the Harvard Medical School began to put similar abnormal genes into mice and showed that they caused tumors. That experiment fascinated me as well: all this was in the 1970s.

I decided to tell the stories of these three patients in order to illustrate that excitement.

Mario

Mario was the 19-month-old son of immigrant parents. He began to look tired; he had intermittent fevers and little red spots on his legs. His parents kept bringing him to his pediatrician who believed that he had a viral infection. Finally Mario's grandmother came over from Austria, took one look at the boy, and said, "This boy is not well." Everybody saluted because she was a very officious woman. They went back to the pediatrician's office and said, "We want a blood test." The result was an enormously high white blood count. Mario had the worst form of leukemia possible.

At the time of his diagnosis, there were almost no survivors of that rare type of childhood leukemia. A young doctor, Scott Arm-

Combination chemotherapy is indeed the answer and with more of these drugs that I call blunderbuss or carpet-bombing drugs, we can now cure 85 percent of children with leukemia.

strong, took over the case. He was particularly interested in research on that type of tumor, as was Stanley Korsmeyer in whose laboratory Armstrong had decided to work. It was happenstance that a doctor who was vitally interested in that particular disease was there for Mario.

Mario's story is about the family's attachment to Scott – he gave the family confidence and made them believe that there was hope for Mario – and it is about the role of nurses, social workers, and psychologists in bringing parents through such a medical crisis. Here is a young couple, both working and trying to get established in America. Then everything is taken away from them; the father loses his job and has no health insurance. There is tremendous pressure on the parents – the divorce rate skyrockets when this occurs because the pins are taken out of people. The institution really has to come to the rescue at that point. My story is about the family situation, but it's also about how we ever got to where we are with these children.

We begin with Sidney Farber, whom I knew very well. He didn't like me much, but he loved my mother. He once said to one of my colleagues, "Dr. Rosen, tell me. How can Dr. Nathan, who is such a terrible man, have such a wonderful mother?" Rosen immediately came to my rescue and said, "Dr. Farber, I have no idea."

Three decades ago, I fought with Dr. Farber over combination chemotherapy. He was single-mindedly determined to get rid of childhood leukemia. He did autopsy after autopsy on these dead children. He was frustrated by the losses and devoted his attention to the search for a smart antileukemic drug, a magic bullet like penicillin. He and a colleague at the then Lederle Laboratories discovered methotrexate, the first anti-cancer drug beyond a congener of mustard gas called nitrogen mustard. It was also one of the first important collaborative relationships between the pharmaceutical industry and academic medicine.

His classic paper published in the *New England Journal of Medicine* in 1946 reported that 11 out of 16 children went into remission on methotrexate, and it became a signal event in cancer treatment. The children eventually relapsed, yet Farber wasn't the least bit daunted. He simply said, "We need more drugs in order to treat these children sequentially and keep them in remission with one smart drug after another."

But methotrexate didn't turn out to be a very smart drug. Methotrexate blocks DNA synthesis in all cells. Because the leukemia cell is sick and dependent on the pathway that is blocked by methotrexate, the drug works; but its toxicity is very high, and the cell can become resistant to a single drug quite easily. I argued that clinical research had already established that we needed more than one drug – we needed combination chemotherapy. In order to prevent resistance, we had to administer the drugs at the same time, not sequentially, because it is unlikely that any cell in the leukemic population can become simultaneously resistant to a combination of drugs. But Dr. Farber feared the toxicity. He could not bring himself to injure many children in order to save a few.

Combination chemotherapy is indeed the answer, and with more of these drugs that I call blunderbuss or carpet-bombing drugs, we can now cure 85 percent of children with leukemia. We used combination chemotherapy on Mario, and we probably cured him. He has been free of leukemia for six years. When Mario was admitted, we were just beginning a new combination chemotherapy program tailored for his severe form of leukemia and wondering whether it might work. Sometimes, as a doctor, you simply have to do the best you can without all the information. That approach worked for Mario but not without toxicity.

Sidney Farber refused to administer combination chemotherapy himself because he was afraid that so many drugs could injure children. And, in fact, the combinations are very toxic. Yet he recruited Emil Frei, a man devoted to combination chemotherapy, as his own replacement. He knew that combination therapy was right, but his ethical standards would not permit him to use it himself.

The success rate in the use of combination chemotherapy for leukemia is not matched in epithelial cancers. We help some epithelial cancer patients, particularly breast cancer patients, with this approach, but epithelial cells become resistant so quickly that even with very toxic combinations, we don't often succeed. Furthermore, unlike leukemia cells, epithelial cells often have mutations in their death genes, and they cannot die. Combination chemotherapy doesn't work well at all in that unfortunate circumstance.

Joan

The subject of my second story, Joan, had lumpy breasts all her life. She had had many mammograms and was repeatedly told she was fine until six years ago, when a technician advised her to repeat the procedure. She had another mammogram and the doctor said, "There's something wrong." When we review all of her mammograms, we can see a cancer developing years before. It was there, but it was a diffuse cancer that didn't form a lump. Mammograms are much more likely to detect lumps. Diffuse cancers, cancers that grow in sheets instead of balls, are much harder to see on a mammogram. So Joan's cancer was not immediately recognized.

The cancer treatment revolution engendered by smart drugs is well on the way.

By the time the diagnosis was made, Joan had metastatic cancer in her affected lymph nodes. What should be her course of action? During my early training in the 1950s, there were no available drugs for breast cancer, one of the most frequent epithelial cancers. Beginning in the 1960s, the tide of ignorance began to turn. First, we learned that combination chemotherapy would help somewhat; second, we found that blocking the estrogen receptors would help massively; and third, we finally realized that the disabling Halsted radical mastectomy was unnecessary. That operation was based on the false idea that breast cancer spreads from the breast outward, moving stepwise to the draining lymph nodes and to other organs. But breast cancer does not spread stepwise; it may be very stable in the breast, or it may spread rapidly and widely. The radical mastectomy persisted on the strength of Halsted's towering reputation until the 1970s, and then it died, largely because women themselves sought other solutions. Now breast specialists, whether surgical, medical, or radiation oncologists, are very conservative about how much breast they remove. Breast cancer is either local or widespread. Much of the most recent progress has come from hormone receptor or growth factor receptor blockage with new smart drugs.

Joan received estrogen receptor blockade, chemotherapy, and radiation to the surgical area, and she is likely to be cured. In the 1950s, we took out ovaries, pituitaries, and adrenal glands; now armed with tamoxifen, an estrogen receptor blocker, we no longer do such surgeries. The massive surgery of the past is gone, and 80 – 85 percent of women are doing extremely well – but not all of them. One type of breast cancer that is associated with excessive production of a growth factor called HER-2/neu is particularly aggressive, but we now have a monoclonal antibody against it called Herceptin. If women with this form of cancer get Herceptin right away and have surgery, they do far better. Tamoxifen and Herceptin are the first really smart drugs in the fight against any form of cancer. They represent major progress in cancer management.

Ken

My last story is about a salesman and ex-wrestler named Ken, who noticed that he was getting tired easily. He went to a doctor who found him anemic. Then the doctor made a serious mistake. He put Ken on iron, which didn't work. Then he started transfusing him. He did not do a proper investigation and didn't realize that there was a huge tumor growing in Ken's abdomen.

One night, while his wife was away, Ken awoke with an indescribable pain in his belly. The tumor had actually eroded into his bowel and opened up so that the whole bowel was leaking into his abdominal cavity. He was dying of shock when the EMTs reached him and took him to a local community hospital. With good fortune, a surgeon on-call took two seconds to say, "I know this is an abdominal catastrophe, and I'm going in there." I like surgeons like that, if they're right.

Ken's entire abdominal cavity had been seeded with cancer cells, but the surgeon saved his life. His wife, however, was at a loss. The pathology came back as gastrointestinal stromal tumor (GIST). That is a very rare sarcoma of the bowel, derived from the nerve cells of the bowel. It is such an unusual tumor that they had never seen it before at this hospital. His wife became very nervous and decided to take Ken to the Dana-Farber Cancer Institute because she thought the physicians there might have seen it. In fact, one of the physicians at Dana-Farber had been doing work on this tumor for several years.

We are beating back many kinds of aggressive cancers with smart drugs, and with adequate funding, we will defeat even more in the years to come.

The story of how GIST was identified dates back to the early nineteenth century and illustrates the interaction of basic science and medicine. In 1910, Peyton Rous, a young pathologist who had been trained at Johns Hopkins, went to Michigan in pathology. Alfred Warthin, Chief of Pathology at Michigan, was an intellectual leader in academic medicine. He took one look at Rous and said, "This is the brightest young man I've ever seen." After he trained Rous, he sent him to the then new Rockefeller Institute (now Rockefeller University). Here was a chance for Rous to be in charge of cancer research at Rockefeller.

At about this time, a strange cancer epidemic had been sweeping through U.S. poultry farms. A farmer brought Rous a cancerous chicken with a wing sarcoma and told him that his whole flock was becoming affected with this tumor. Rous concluded that it must be an infection, but nobody believed that infectious agents caused tumors. So Rous did a classic experiment: he took the tumor off the chicken – this is a Judah Folkman type of experiment. He crushed it up, suspended the chopped cells in water, and then filtered it until there were no cells left. Next he injected the seemingly empty water into another chicken, and it promptly developed a tumor. He concluded that a virus caused the tumor, but he was laughed out of court – even certain members of the Rockefeller faculty laughed at him. Rous was then about 22 years old. After many years of additional research, scientists began to recognize that tumor viruses could cause cancer. At the age of 83, Rous received a Nobel Prize for his discovery.

Ken's story starts with cancerous hens. Years later, another discovery occurred: the chicken tumor was driven by a particular growth factor called a tyrosine kinase, an ATP (adenosine-5-triphosphate) splitting enzyme that passes signals down the line to the cell nucleus to tell the cell to divide. This virus, it turns out, was actually carrying such a kinase.

The mechanism by which the Rous sarcoma virus actually causes cancer was discovered in the 1970s by Harold Varmus and Michael Bishop, who also received the Nobel Prize. It took 50 years of work to come to that conclusion, and it became part of the whole molecular biology revolution.

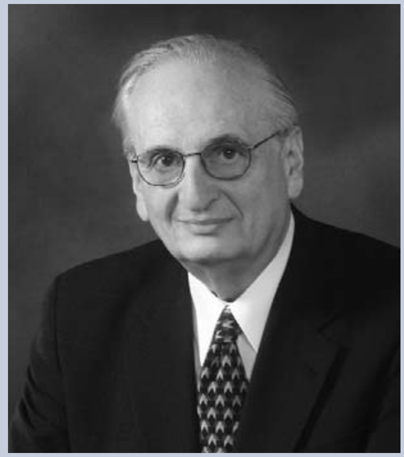
Now we flash back to the 1960s when investigators in Philadelphia and Chicago examined a peculiar leukemia called chronic myelogenous leukemia (CML) in a microscope. They saw something bizarre about this tumor. Two chromosomes are crossed and exchange segments. An abnormal gene is created in that crossover. Through the work of David Baltimore and others in the 1980s, we learned that this abnormal gene is another activated tyrosine kinase. About this time, Novartis became interested and thought, "Maybe we can inhibit these kinases with drugs." Novartis requested a very simple assay for kinase activity from two investigators at Dana-Farber, indicating "we'll robotize it and find out if there are any drugs that inhibit it." They developed the drug Gleevec.

Brian Drucker, a medical oncology fellow at Dana-Farber became interested and asked if he could try the drug on some leukemia cells. At first, Novartis refused, but eventually they relented and gave him the drug. Drucker killed every leukemia cell in the dish with that drug. He then insisted on running clinical trials. Next thing I knew, Drucker was on the cover of *Time*. It was the biggest discovery in cancer treatment in the last five years. We used to do bone marrow transplants on patients with chronic leukemia; we don't do them anymore. All patients with CML now start on Gleevec and many remain in long-term remission. Some develop resistance. From that one observation came many smart anticancer drugs that you are reading about today.

Ken was treated with Gleevac in 2000, but he developed resistance to it and eventually died in 2005. He was a vanguard of the revolution in smart-drug treatment for cancer, but his story reiterates the necessity for combination therapy to prevent resistance – the lesson that was learned a half century earlier by those who attacked the then-intractable childhood leukemias. But the cancer treatment revolution engendered by smart drugs is well on the way.

I want to conclude this talk by returning to Judah Folkman. Judah simply bypassed this approach. He focused on the fact that all cancers need blood to survive, and he maintained that the best thing to do is to kill the blood supply because the blood vessels that are feeding the cancer are not mutated themselves. They are, therefore, not susceptible to becoming resistant. If they are killed, the tumor will die. I would say to Judah: "It's the tumor that's calling the blood vessels, not the blood vessels calling the tumor." Obviously I wasn't completely right because on the way to that solution, look at what happened with wet macular degeneration, which we are curing directly because of his ideas. I think he would have won the Nobel Prize for that discovery.

I have remained terribly excited about the progress we are making in the cancer revolution. We are going to get there. We are slowed down only by the cost of our inefficient medical care system, which is an enormous financial challenge. We are beating back many kinds of aggressive cancers with smart drugs, and with adequate funding, we will defeat even more in the years to come if we can devote sufficient resources to the task. ■



M. Judah Folkman
1933 – 2008

The Academy mourns the loss
of its esteemed and active member
M. Judah Folkman

Noteworthy

Select Prizes and Awards

Presidential Medal of Freedom

Anthony S. Fauci (National Institutes of Health)

Donna E. Shalala (University of Miami)

Other Awards

Vladimir I. Arnold (Steklov Mathematical Institute, Moscow, Russia) is among the recipients of the 2008 Shaw Prize in Mathematical Sciences.

J. Richard Bond (Canadian Institute for Theoretical Astrophysics) is the recipient of the 2008 Gruber Cosmology Prize, awarded by the Peter and Patricia Gruber Foundation.

Nancy Cantor (Syracuse University) is the recipient of the 2008 Carnegie Corporation Academic Leadership Award.

Jean-Pierre Changeux (Institut Pasteur, France) is among the recipients of the Neuronal Plasticity Prize, awarded by La Fondation Ipsen.

Joseph M. DeSimone (University of North Carolina at Chapel Hill) was awarded the Lemelson-MIT Prize.

Ludwig D. Faddeev (Euler International Mathematical Institute, St. Petersburg, Russia) is among the recipients of the 2008 Shaw Prize in Mathematical Sciences.

Michael Gazzaniga (University of California, Santa Barbara) received the Humboldt Research Prize from the Alexander von Humboldt Foundation of Germany.

Robert Langer (Massachusetts Institute of Technology) was awarded the Millennium Technology Prize.

Eric J. Nestler (University of Texas Southwestern Medical Center) is among the recipients of the Neuronal Plasticity Prize, awarded by La Fondation Ipsen.

Howard Raiffa (Harvard University) is the recipient of the Thomas C. Schelling Award, presented by the Harvard Kennedy School.

Bernard Roizman (University of Chicago) received the Abbott-American Society for Microbiology Lifetime Achievement Award.

Donna E. Shalala (University of Miami) was awarded the 2008 Radcliffe Institute Medal.

Allan C. Spradling (Carnegie Institution of Washington) was awarded the 2008 Gruber Prize in Genetics, by the Peter and Patricia Gruber Foundation.

New Appointments

Alan S. Blinder (Princeton University) joined the Board of Directors of On Deck Capital.

Linda Greenhouse (formerly, *New York Times*) was appointed Knight Distinguished Journalist in Residence and Joseph M. Goldstein Senior Fellow in Law at Yale Law School. In July 2008 she concluded a 40-year career at *The New York Times*, the last 30 as the newspaper's Supreme Court correspondent.

Leroy Hood (Institute for Systems Biology) was elected to the Board of Directors of Geospiza, Inc.

Marsha I. Lester (University of Pennsylvania) has been named editor of *The Journal of Chemical Physics*.

William Wulf (University of Virginia) has been elected Chair of the Board of Trustees of the Anita Borg Institute for Women and Technology.

Select Publications

Poetry

Richard Howard (New York, New York). *Without Saying*. Turtle Point Press, October 2008

Sharon Olds (New York University). *One Secret Thing*. Knopf, September 2008

Susan Stewart (Princeton University). *Red Rover*. University of Chicago Press, September 2008

Fiction

Paul Auster (New York, New York). *Man in the Dark*. Holt, August 2008

John Barth (Chestertown, Maryland). *The Development*. Houghton Mifflin, October 2008

Carl Djerassi (Stanford University). *Sex in an Age of Technological Reproduction : ICSI and Taboos*. University of Wisconsin Press, September 2008

Carlos Fuentes (University of Cambridge, United Kingdom). *Happy Families*. Random House, October 2008

Diane Johnson (Bolinas, California). *Lulu in Marrakech*. Dutton, October 2008

Garrison Keillor (Prairie Home Companion). *Liberty : A Lake Wobegon Novel*. Viking Adult, September 2008

Philip Lopate (Hofstra University). *Two Marriages : Novellas*. Other Press, September 2008

Francine Prose (New York, New York). *Goldengrove*. Harper, September 2008

Philip Roth (New York, New York). *Indignation*. Houghton Mifflin, September 2008

John Updike (Boston, Massachusetts). *The Widows of Eastwick*. Knopf, October 2008

Nonfiction

Henry J. Aaron (Brookings Institution) and Jeanne M. Lambrew (University of Texas, Austin) with Patrick F. Healy (Brookings Institution). *Reforming Medicare : Options, Tradeoffs, and Opportunities*. Brookings Institution Press, May 2008

Peter Ackroyd (*London Times*, United Kingdom). *Thames : The Biography*. Doubleday/Talese, November 2008

Edgar M. Bronfman (Vivendi Universal) and Beth Zasloff (New York, New York). *Hope, Not Fear : A Path to Jewish Renaissance*. St. Martin's Press, September 2008

Zbigniew Brzezinski (Center for Strategic and International Studies), Brent Scowcroft (The Scowcroft Group), and David Ignatius (*Washington Post*). *America and the World : Conversations on the Future of American Foreign Policy*. Basic Books, September 2008

Robert Dallek (Boston University). *Harry S. Truman* (The American Presidents Series). Times Books, September 2008

Arthur C. Danto (Columbia University) and Ralph Rugoff (Hayward Gallery, London). *Tom Friedman*. Yale University Press, August 2008

Stanley Fish (Florida International University). *Save the World On Your Own Time*. Oxford University Press, September 2008

Eric Foner (Columbia University), ed. *Our Lincoln : New Perspectives on Lincoln and His World*. W. W. Norton, October 2008

Herbert J. Gans (Columbia University). *Imagining America in 2033 : A Utopian Narrative*. University of Michigan Press, July 2008

Allan Gibbard (University of Michigan). *Reconciling Our Aims : In Search of Bases for Ethics*. Oxford University Press, September 2008

Donald Hall (Wilmot, New Hampshire). *Unpacking the Boxes: A Memoir of a Life in Poetry.* Houghton Mifflin, September 2008

Bert Hölldobler (Arizona State University) and **Edward O. Wilson** (Harvard University). *The Superorganism: The Beauty, Elegance and Strangeness of Insect Societies.* W. W. Norton, November 2008

Jacqueline Jones (University of Texas at Austin). *Saving Savannah: The City and the Civil War.* Knopf, October 2008

Louis Kaplow (Harvard University). *The Theory of Taxation and Public Economics.* Princeton University Press, June 2008

Anthony Kenny (University of Oxford, United Kingdom). *Philosophy in the Modern World.* Oxford University Press, November 2008

Charles Larmore (Brown University). *The Autonomy of Morality*. Cambridge University Press, August 2008

Robert B. Laughlin (Stanford University). *The Crime of Reason and the Closing of the Scientific Mind*. Basic Books, October 2008

Glenn C. Loury (Brown University) with **Pamela Karlan** (Stanford Law School), Thomas Shelby (Harvard University), and Loïc Wacquant (University of California, Berkeley). *Race, Incarceration, and American Values*. MIT Press, September 2008

J. D. McClatchy (Yale University), ed. *The Whole Difference: Selected Writings of Hugo Von Hofmannsthal*. Princeton University Press, December 2008

Alicia H. Munnell (Boston College) and Steven Sass (Center for Retirement Research). *Working Longer: The Solution to the Retirement Income Challenge*. Brookings Institution Press, May 2008

Robert F. Nagel (University of Colorado). *Unrestrained: Judicial Excess and the Mind of the American Lawyer.* Transaction Publishers, May 2008

Mark A. Noll (University of Notre Dame). *God and Race in American Politics: A Short History.* Princeton University Press, September 2008

Norman J. Ornstein (American Enterprise Institute for Public Policy Research), **Thomas E. Mann** (Brookings Institution), and Michael J. Malbin (Campaign Finance Institute). *Vital Statistics on Congress 2008.* Brookings Institution Press, September 2008

Annabel Patterson (Yale University). *The Long Parliament of Charles II.* Yale University Press, September 2008

Nicholas Penny (The National Gallery, London) and Eike D. Schmidt (J. Paul Getty Museum). *Collecting Sculpture in Early Modern Europe.* Yale University Press, June 2008

Ellen Rosand (Yale University). *Monteverdi's Last Operas: A Venetian Trilogy.* University of California Press, December 2007

Nancy L. Rosenblum (Harvard University). *On the Side of the Angels: An Appreciation of Parties and Partisanship.* Princeton University Press, October 2008

Robert Rotberg (Harvard University), ed. *China into Africa: Trade, Aid, and Influence.* Brookings Institution Press, October 2008.

Ingrid D. Rowland (University of Notre Dame, Italy). *Giordano Bruno: Philosopher/Heretic*. Farrar, Straus & Giroux, August 2008

David Ruelle (Institut des Hautes Études Scientifiques). *The Mathematician's Brain: A Personal Tour through the Essentials of Mathematics and Some of the Great Minds Behind Them.* Princeton University Press, September 2007

Marshall D. Sahlins (University of Chicago). *The Western Illusion of Human Nature.* Prickly Paradigm Press, June 2008

Howard Schuman (University of Michigan). *Method and Meaning in Polls and Surveys.* Harvard University Press, June 2008

Charles Simic (University of New Hampshire). *The Monster Loves His Labyrinth: Notebooks.* Ausable, September 2008

Nancy L. Stokey (University of Chicago). *The Economics of Inaction: Stochastic Control Models with Fixed Costs*. Princeton University Press, December 2008

Leonard Susskind (Stanford University). *The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics.* Little, Brown, July 2008

Susan Treggiari (University of Oxford, United Kingdom). *Terentia, Tullia and Publilia: The Women of Cicero's Family*. Routledge, May 2007

Laurence H. Tribe (Harvard University). *The Invisible Constitution.* Oxford University Press, September 2008

Rosanna Warren (Boston University). *Fables of the Self: Studies in Lyric Poetry.* W. W. Norton, September 2008

Frank Wilczek (Massachusetts Institute of Technology). *The Lightness of Being: Mass, Ether, and the Unification of Forces*. Basic Books, September 2008

Exhibitions

Philippe de Montebello (Metropolitan Museum of Art): *The Philippe de Montebello Years: Curators Celebrate Three Decades of Acquisitions* at the Metropolitan Museum of Art, October 24, 2008 through February 1, 2009.

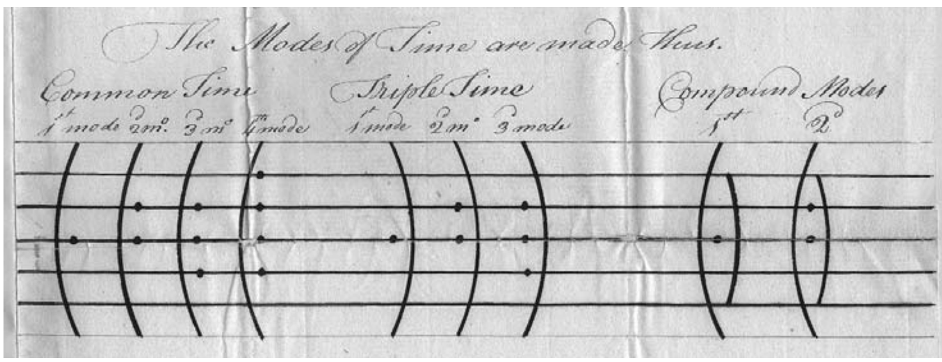
We invite all Fellows and Foreign Honorary Members to send notices about their recent and forthcoming publications, scientific findings, exhibitions and performances, and honors and prizes to bulletin@amacad.org.

From the Archives

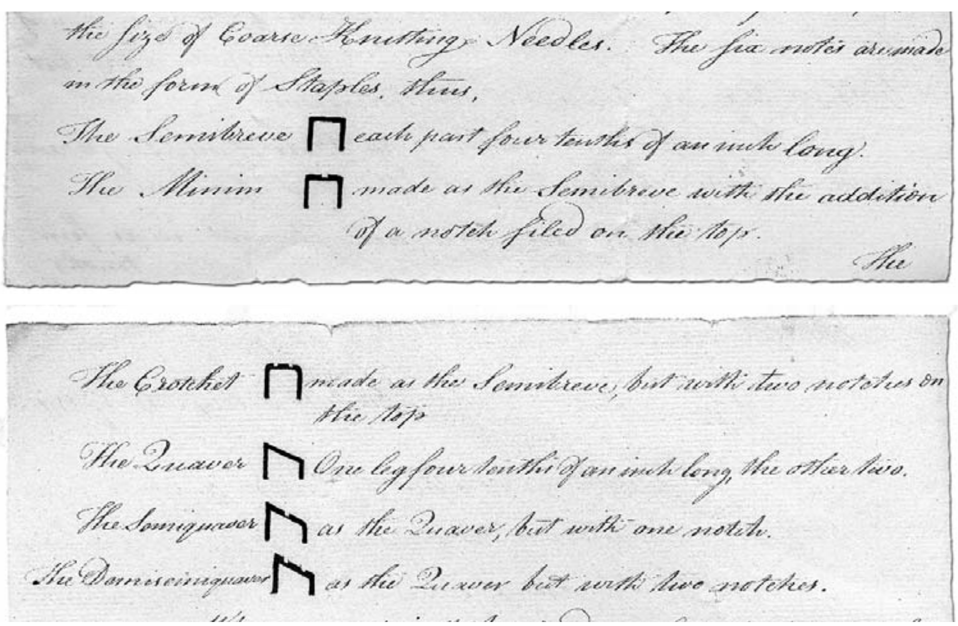
Benjamin Dearborn, an educator and inventor who was elected to the Academy in 1794, wrote to Academy President John Adams on August 19, 1794, and described his design for a "Music Board" for the benefit of blind people.

> On presumption that an attempt which may in any measure alleviate the Calamities of Life, will be countenanced by the Academy, I have constructed the Music Board which is presented herewith for the benefit of the Blind; whereby all Notes and other necessary Characters in Music, with their Respective Stations on Lines or Spaces, are Readily Ascertained with great Precision, by a Touch of the Fingers.

Dearborn constructed the music board out of pine, using a sharp instrument to incise the lines of the staff. In his letter he described in great deal the design of notes and other characters, which he made out of brass wire, as well as their placement into holes along the lines. He also explained his method of indicating modes of time.


The Modes of Time are made thus.
Common Time 1st mode 2m. 3m. 4th mode
Triple Time 1st mode 2m. 3 mode
Compound Modes 1st 2d

Modes of time on Dearborn's Music Board


the size of Coarse Knitting Needles. The few notes are made in the form of Staples, thus,
The Semibreve each part four tenths of an inch long.
The Minim made as the Semibreve with the addition of a notch filed on the top.
The
The Crotchet made as the Semibreve, but with two notches on the top
The Quaver One leg four tenths of an inch long, the other two.
The Semiquaver as the Quaver, but with one notch.
The Demisemiquaver as the Quaver but with two notches.

Design of musical notes

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