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Bulletin

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Induction Ceremony 2017

Class Speakers: Jane Mayer, Ursula Burns, James P. Allison, Heather K. Gerken, and Gerald Chan

Annual David M. Rubenstein Lecture

Looking at Earth: An Astronaut's Journey

David M. Rubenstein and Kathryn D. Sullivan

ALSO:

Upcoming Events

MARCH

1st

California Institute of Technology
Pasadena, CA

Bryson Symposium on Climate and Energy Policy

Featuring: **Dallas Burtraw** (Resources for the Future), **Ralph Cavanagh** (NRDC), **Nathan S. Lewis** (California Institute of Technology), **Mary Nichols** (California Air Resources Board), **Ronald O. Nichols** (Southern California Edison), **Thomas F. Rosenbaum** (California Institute of Technology), and **Maxine L. Savitz** (Honeywell, Inc., *ret.*; formerly, President's Council of Advisors on Science and Technology)

7th

American Academy
Cambridge, MA

Building, Exploring, and Using the Tree of Life

Featuring: **Douglas E. Soltis** (University of Florida) and **Pamela S. Soltis** (University of Florida; Florida Museum of Natural History)

22nd

American Academy
Cambridge, MA

Book Talk: Why Are All the Black Kids Sitting Together in the Cafeteria? And Other Conversations About Race

Featuring: **Beverly Daniel Tatum** (Spelman College)

APRIL

12th

American Academy
Cambridge, MA

Annual Awards Ceremony: A Celebration of the Arts and Sciences

Featuring: **Martha C. Nussbaum** (University of Chicago), recipient of the Don M. Randel Award for Humanistic Studies; and **Barbara J. Meyer** (University of California, Berkeley), recipient of the Francis Amory Prize in Medicine & Physiology

MAY

3rd

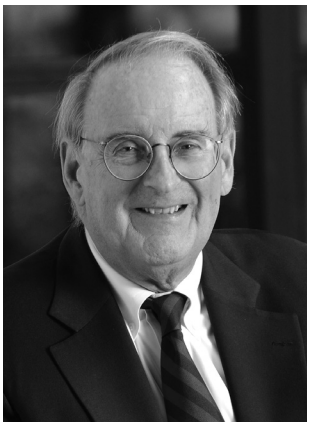
American Academy
Cambridge, MA

Songs of Love and Death: Sonnets by Petrarch and Others Set by Cipriano de Rore in "I madrigali a cinque voci" (Venice, 1542)

Featuring: **Jessie Ann Owens** (University of California, Davis) and the vocal ensemble **Blue Heron**

For updates and additions to the calendar, visit www.amacad.org.

From the President



Jonathan F. Fanton

In January, I had the opportunity to visit with students and faculty at European Humanities University (EHU) in Vilnius, Lithuania. As a university-in-exile from an authoritarian regime in Belarus, EHU provides a college education in the liberal arts tradition to students from Belarus and the surrounding region. I was moved to meet so many young people inspired by their opportunity for intellectual exchange in a free and democratic environment. My visit prompted new reflections about how fundamental and important the work of the Academy is in strengthening and sustaining democracy in the United States.

The Academy is engaged in a number of projects, studies, and meetings that, when taken together, support the quality education and informed exchange that shape a healthy and inclusive democratic society. Just recently the Academy announced a Commission on the Practice of Democratic Citizenship, led by Danielle Allen of Harvard University, Stephen Heintz of the Rockefeller Brothers Fund, and Eric Liu of Citizen University. The Commission brings together a diverse group of leading scholars and practitioners who will work across disciplines to develop an understanding of how native-born and newly arrived Americans engage with the institutions of their democracy, and how they exercise their rights and responsibilities as citizens. The Commission will emphasize new forms of civic engagement and democratic practice made possible through new technologies. This is an important time for the Academy to examine what it means to be a citizen in a twenty-first century democracy. I look forward to learning from the Commission and to sharing its work with you.

A healthy and diverse democratic society thrives with the support of a strong educational system. In November 2017, the Academy's Commission on the Future of Undergraduate Education, led by Roger W. Ferguson, Jr. of TIAA and Michael S. McPherson, formerly of the Spencer Foundation, released a report with a national strategy for improving the quality and affordability of students' educational experiences. The report, *The Future of Undergraduate Education, The Future of America*, emphasizes the importance of preparing undergraduates to be informed and engaged citizens who understand the values, skills, and behaviors that contribute to a healthy democracy. To participate fully in society, citizens now need real scientific and technological understanding, sophisticated critical thinking skills, and a working knowledge of history, economics, civics, and the arts. Equally important, citizens need educational institutions that welcome and protect a robust and respectful exchange of ideas – the very essence of a democracy. And in an increasingly diverse population, undergraduate education is a good setting in which the next generation learns empathy and respect for people of different backgrounds.

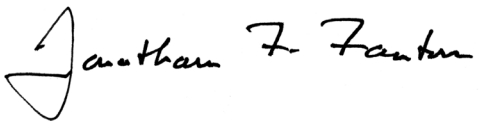
The Academy's Public Face of Science project, led by Richard A. Meserve, formerly of Carnegie Institution for Science, and Geneva Overholser of Democracy Fund, considers how the public develops trust or mistrust in science, and in evidence more broadly. In a media landscape in which fact and fiction are not easily distinguishable, careful analysis of evidence and reasoned debate have become essential to civil dialogue. In February 2018, the Academy released the first of a series of reports from the Public Face of Science project, *Perceptions of Science in America*. The report explores the degree to which a person's background and experiences shape his or her interpretation of science. The goal of the project is to help scientists communicate better with citizens who depend on a working knowledge of scientific issues to make informed decisions for themselves and their communities.

A healthy democratic society also depends on global security and stability. The Academy has recently launched a three-year initiative on Meeting the Challenges of the New Nuclear Age, led by Christopher Chyba of Princeton University and Robert Legvold of Columbia University. The goal of the project is to articulate a new framework for governing relations among the existing nine nuclear weapons states, with particular attention to strengthening strategic stability within the two critical nuclear triangles:

China, the United States, and Russia; and India, Pakistan, and China. The project is deeply rooted in the critically important work the Academy conducted during the Cold War to prevent a nuclear confrontation between the United States and the Soviet Union and beyond. It is now more important than ever that the Academy take up the challenge of understanding this new nuclear age.

The Academy also holds meetings in Cambridge and around the country on topics of pressing importance to our democracy. In November 2017, the Academy held a Stated Meeting on "Redistricting and Representation" featuring presentations from the Honorable Patti B. Saris of the U.S. District Court for the District of Massachusetts, Gary King of Harvard University, Jamal Greene of Columbia Law School, and Moon Duchin of Tufts University. I invite you to read their insightful presentations in this issue of the *Bulletin*. In February 2018, the Academy held a Stated Meeting on "Jefferson, Race, and Democracy," and in March 2018, the Academy looks forward to hosting the Bryson Symposium on Climate and Energy Policy at the California Institute of Technology. The Academy's local program committees are also developing thoughtful and substantive programs: the New Haven Committee held a luncheon in December 2017 on "Gains from Trade and Inequality"; the San Diego Committee organized a conversation in February 2018 on "Why are America's Politics Polarized?" and the Princeton Committee in February 2018 hosted a panel on "Research, Truth, and Academic Freedom."

We live in an uncertain time when the public and policy-makers are turning to independent, trusted institutions like the Academy for perspective and evidence. We should be proud that our Members are rising to this challenging moment with studies and publications, which are, in the words of our founders, "necessary to the wealth, peace, independence, and happiness of a people."



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Update on Members

Induction Ceremony 2017: Presentations by New Members

On October 7, 2017, the American Academy inducted its 237th class of Members at a ceremony held in Cambridge, Massachusetts. The ceremony featured historical readings by **Kathryn Fuller** (Smithsonian Institution's National Museum of Natural History) and **John Lithgow** (Actor and Author) as well as a performance by the Boston Children's Chorus. The ceremony also included presentations by five new Members: **Ursula Burns** (Xerox Corporation), **James P. Allison** (University of Texas MD Anderson Cancer Center), **Heather K. Gerken** (Yale Law School), **Jane Mayer** (*The New Yorker*), and **Gerald Chan** (Morningside).

Ursula Burns

Ursula Burns served as Chairman of the Board of Xerox Corporation from 2010 to 2017 and as Chief Executive Officer from 2009 to 2016. She was elected a Fellow of the American Academy in 2017.

We must do a better job of exploiting our most valuable natural resource – the curious young minds who are churning through our school systems. Exploiting that resource will mean imagining our youth differently.

Growing up in public housing on New York's Lower East Side, I did not envision that one day I would be standing before a group of 228 such distinguished leaders. Come on – John Legend, Lynn Nottage, Carol Burnett. This is not exactly the group I expected to find myself among when I was a little girl in the Baruch Houses. I am honored and humbled that this year's inductees, the Academy's 237th class of Members, selected me to deliver this short address. In fact, that is exactly what I would like to speak to you about today – expectations.

I am different from most of my classmates. I am an engineer, but not a true scientist. I am not an artist. I cannot sing or dance, and I cannot even carry a tune. I suppose that is part of what interested the Academy in me – that I am different.

We are moving to a place in society, in the United States and globally, where more space is being made for people who are different. As we do so, I would like to lay bare some of the challenges that we face and consider those challenges in a positive light: a light of possibilities versus criticism or exclusion.

The "normal" – meaning the status quo of the world from the point of view of governance, money, power, beauty, grace, etc. – is comprised of a shrinking set of individuals. Many of these individuals have been good and strong stewards of the world. They created much of the value that we see around us, but the future cannot depend on them. There are not enough of them, and the number of people who are not like them is growing. In order to get this new class of leaders prepared, we have to do something differently. We cannot just sit around and hope. We cannot limit access to what it is going to take to develop and participate fully in the magnificent opportunities that exist in society.

Our efforts must be focused on preparing future generations for the responsibilities that they have going forward. One of the most important areas that they must focus on is STEM: science, technology, engineering, and math. We still need – actually, we require – artists, artisans, creative people, and soft scientists. We need all these types of people. But I think we particularly need people who can take all of those assets and transform them into usable short- and intermediate-term resources for societies. We are doing a very poor job of developing these people and a particularly poor job among women and underrepresented minorities. I am not referring only to, say, black and brown women and men in America. Underrepresented minorities can refer to an Algerian in France or a woman in Saudi Arabia. There are so many human assets that we are not using well, and it is hurting the world, and specifically our country.

We will all benefit from the creativity and productivity unleashed when all Americans are called upon to contribute.

The numbers are not pretty. On the most recent PISA (Program for International Student Assessment) test, American fifteen-year-olds ranked thirty-eighth out of seventy-one developed and developing countries in math and twenty-fourth in science. Of the thirty-five members of the Organization for Economic Cooperation and Development, the United States ranked thirtieth in math and nineteenth in science.[1]

We must do a better job of exploiting our most valuable natural resource – the curious young minds who are churning through our school systems. Exploiting that resource will mean imagining our youth differently. I am a good example of how that imagination might pay off – for all of us.

Conventional wisdom might have made it easy for my teachers and other adults in my life to discard any potential they might have seen in me. I came from a place that had not produced many scientists or CEOs. My mother struggled just to keep us together and fed in an environment that was unsafe and desperately poor. I benefited from the belief in me by people who saw something different, who saw some value. Adults who said, "Yeah, just because she lives there is not going to define who she is. The fact that her mother is a single mother who doesn't have any skills to participate at a high level does not mean that her family has no drive, discipline, and intellect – all the things that make you both a good human being and a success."

Those people who took a chance on me are just like the people in this room. And so I challenge each of you to do the same. Expose yourselves to people who might be overlooked. Avail yourselves of their talents. Open yourselves to envisioning them in a future different from the one that seems preordained by their economic and family circumstances. Build the kinds of institutions that benefited people like me – like the Henry Street Settlement – and support these organizations. Not just because it is kind. Not just because it is the right thing to do. But because we will all benefit from the creativity and productivity unleashed when all Americans are called upon to contribute.

1. Drew DeSilver, "U.S. Students' Academic Achievement Still Lags that of Their Peers in Many Other Countries," Pew Research Center, February 15, 2017, http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/.

James P. Allison

James P. Allison is Chair of the Department of Immunology, the Vivian L. Smith Distinguished Chair in Immunology, Director of the Parker Institute for Cancer Research, and the Executive Director of the Immunotherapy Platform at the University of Texas MD Anderson Cancer Center. He was elected a Fellow of the American Academy in 2017.

We must continue to support basic science, since it is clear that it can have a major impact on society. We also need to remember that science is based on facts. The current anti-fact movement is very troubling, and we must resist. We owe it to the next generation of scientists and to our own future.

I am so glad to be here and very honored to be selected for membership in the American Academy of Arts and Sciences. I am also honored to represent Class II: the Biological Sciences.

In 2006, I had the opportunity to meet a patient by the name of Sharon. She was twenty-four-years old and had recently graduated from college and gotten married. More than a year before I met her, she was told by her doctors that she had only a few months to live. Sharon had stage 4 metastatic melanoma, with tumors in her brain, lungs, and liver. With such a diagnosis, her projected survival was less than a year. She had received multiple prior therapies but her cancer continued to grow and weaken her body.

As a last ditch effort, she participated in a clinical trial of a new drug called anti-CTLA-4 therapy. Within three months of starting treatment, her tumors shrank in size and then disappeared. When I met her she hugged me and cried. She was alive and her doctors had just told her that they did not see any evidence of recurrent cancer on her CAT scans. I was so moved, I cried with her.

Sharon and I have become good friends. When her first child was born a few years later, she sent me pictures. Then pictures of her second child. She is now eleven years out from her battle with cancer and enjoying life with a vibrant family. I cannot help but cry whenever I tell this story. My meeting with Sharon was my first experience of how years of research as a basic scientist could have an impact on patients.

When I was a child, I was fascinated by science and biology and spent a lot of time collecting bugs, lizards, and snakes and playing with my Gilbert chemistry set in the garage. My father was a local family doctor and he had high hopes that I would go to medical school. But as I thought about it after entering college as a pre-med major, I realized that doctors had to have a lot of facts in their heads and respond to a patient's presentation with a rational treatment algorithm. They had to be right all the time in order to help and not hurt the patient. I was pretty sure that I was not disciplined enough to do this. I preferred the idea of being a scientist. Scientists are supposed to come up with novel ideas and test them, and go through the process of realizing that they are going to be wrong most of the time. If you are not wrong a lot as a scientist, then you are probably not working on important questions.

In the beginning of my career in the late 1970s, the field of cellular immunology was still in its infancy. There was the concept of T cells, which were cells that circulated throughout your body looking to remove foreign antigens related to bacteria and viruses and potential cancer cells. I was intrigued. It was a mystery as to how T cells worked. In the early 1980s, my lab identified and worked out the structure of the receptor that T cells used to identify foreign antigens. But it was not that simple. A T cell receptor may be compared to the ignition switch of a car. It is needed to turn the car on and start the process of T cell activation but it is not enough to get it going. It seemed that another signal was needed. We showed that another molecule, CD28, was the accelerator that enabled T cells to take off and proliferate to generate an army of cells that can then do their jobs and attack the invaders that are in your body.

But that is not the end of the story. There had to be a mechanism to stop the rapid proliferation of T cells. Many people thought that T cells just died, but in 1994 we identified another signal, called CTLA-4, and showed that it acted as a brake to stop T cell responses before they could cause any damage. I had one of those aha moments. Nu-

merous attempts had been made to mobilize T cells to treat cancer, but with disappointing results. It occurred to me that if we could block the brakes, we could allow T cells to keep going for sufficient periods of time and destroy large tumors.

We tested this idea in mice with an antibody we made to CTLA-4, and it worked beautifully to destroy tumors in mice. We could not believe the results! Many tumors just melted away, and the mice were permanently immune to rechallenge.

We eventually teamed up with a small biotech company to move CTLA-4 blockade therapy into clinical trials. And, as they say, the rest is history! We now know that the therapy is effective against many types of cancer, and some patients are alive a decade or more after treatment.

I have had the privilege of meeting many patients who have benefited from anti-CTLA-4 therapy. It is always overwhelming, and my emotions often get the best of me as they tell me their stories.

Additional CTLA-4-like brakes have been identified and antibodies to these are showing remarkable benefits in patients. These drugs, now known as checkpoint blockade therapy, treat the immune system not the cancer, and as a result they can be effective against many kinds of cancer. Checkpoint blockade agents are now approved for many different cancers, including melanoma, kidney cancer, bladder cancer, Hodgkin's lymphoma, lung cancer, and others.

Of course, we still have a lot of work to do. We have not been able to treat successfully cancers such as pancreatic cancers and glioblastoma. We are continuing our efforts and hope to make progress in the near future.

But I would like to point out that all of this comes from basic science. It is therefore necessary for us to continue to support basic science, since it is clear that it can have a major impact on society. We also need to remember that science is based on the notion that there is such a thing as objective reality. Science is based on facts. The current anti-fact movement is very troubling, and we must resist. We owe it to the next generation of scientists and to our own future.

I am truly honored to have been selected as a member of this august body of individuals committed to making a better society. Thank you for this wonderful honor. I owe this success to a large number of students and fellows who worked in my lab, as well as to several colleagues. And I owe special thanks to my wonderful partner in science, and love, my wife Pam Sharma.

Heather K. Gerken

Heather K. Gerken is Dean and Sol & Lillian Goldman Professor of Law at Yale Law School. She was elected a Fellow of the American Academy in 2017.

Universities have always been places that strike the balance between arguments and truth. They are one of the few remaining spaces where we can question everything and still believe in something. Now is the time to protect those spaces, to insist on their importance, even if it requires us to take up an unaccustomed role of speaking out.

It is an honor to be here and to speak on behalf of this class of Members. I know you all feel as I do at this moment. This is a storied institution, and we all were worried about living up to this honor even before we walked in here. Now we are following a pathbreaker and a man who cured cancer. When you add in David Souter, John Lithgow, and bagpipes, it gets intimidating.

I also would like to thank Justice Souter. It must now be clear why every one of his clerks would throw themselves in front of a bus for him, whom we have always affectionately called "Boss." He is a man who did not take a break from his duties for his OWN induction into the American Academy, but he came here for me. In all my years, Boss, I never imagined a situation in which *you* would be introducing *me*.

I approach this moment with some trepidation since I am a law professor speaking on behalf of a gathering of some of the best social scientists in the world. Law professors are the black sheep of the academic tribe. We are often cloistered in our own (more expensive) buildings. We publish in our own (student-edited) journals. We even speak in our own academic language. We work in the dreaded "professional" schools, not graduate schools.

You might even think that a legal academic is a contradiction in terms. Don't legal academics teach the profession damned as "hired guns"? Aren't we the ones who teach our students to advocate for everything while believing nothing? How does one reconcile a lawyer's professional training with the academic's highest call – the quest for truth?

I recognize that a call for truth, and not merely a quest for it, will strike some of you as unduly earnest. It strikes me as unduly earnest, or at least dreadfully retro. Perhaps it is even outside the bounds of what a scholar should normally say. Academics are – and should be – cautious about labeling anything as truth. Our job is to be skeptical, to resist labels, to avoid putting ideas and arguments outside the bounds of inquiry. Labeling something as "truth" risks shutting down the argument that might reveal it as otherwise.

But we are at a strange moment in our political history when facts, evidence, and expertise are all under attack. The slide from "truthiness" to Fake News has been lightning quick. We live in a time when expertise is not just challenged; it has become grounds for doubt. Meanwhile other parts of the political spectrum watch us allowing arguments over core values to occur and doubt we have any values in the first place. We are being whipsawed by these two extremes. That is why it is a time for universities to speak to the values that undergird their mission, to talk about the balance between argument and truth, to explain why we both have values and yet question them.

Needless to say, speaking out is not what universities are used to doing. Taking a position is uncomfortable for institutions that typically adopt a studied neutrality toward the world. That challenge reproduces at an institutional level what we all experience as individuals and scholars. At this moment in time, we are all thrust into an uncomfortable and yet critical position of protecting the right to argue while insisting on the existence of truth.

When I think about the challenges of being an academic at this moment – how hard it is to find the balance between argument and truth, between holding values and questioning them – I find deep continuities between the work of a lawyer and the work of an academic. Because even though lawyers are taught to question everything, they also believe in something. And they stand up for their commitments. Just look at what is happening worldwide. When countries

start to slide into authoritarianism, you will often see lawyers – the people taught to argue for any side – standing up on behalf of rule of law values. How is it that members of a profession taught to doubt are the ones who put their bodies on the line for what they believe?

It has to do with our training. The training of a lawyer is much like the training of an academic. From the first moment our students walk into a classroom, lawyers are trained not just to understand the weaknesses in their own arguments, but to imaginatively and sympathetically reconstruct the best argument on the other side. From the first day in class, students must defend an argument they do not believe, or pretend to be a judge whose values they dislike. We try to develop enough distance from our own commitments to recognize what is honorable in the commitments of our opponents. We check ourselves habitually, almost reflexively.

But lawyers are committed to rule-of-law values no matter what our party or our preferences. How is it that faithless lawyers have faith in something? It is simple. Our profession has argued about values for generations. After centuries of laying waste to every argument, we see that some are left standing. They are the claims for which a profession trained to identify every counterargument cannot find a counter. They are what remains when there is no argument on the other side.

I won't belabor the comparison, but it must be obvious to you by now that what makes for a great lawyer also makes for a great academic: the ability to develop enough distance from our own commitments to recognize what is honorable in the commitments of the other side; the ability to subject everything we believe to challenge. But being a great lawyer and a great academic also requires the ability to recognize when there is no argument on the other side. When a position is indefensible.

And perhaps now is the moment to take a lesson from the lawyers about striking the balance between argument and truth, between holding values and questioning them. Perhaps it is time to stand up for truth even though our job is to disagree about what truth is.

John Adams – the Bostonian statesman who helped found this academy – once said that "facts are stubborn things, and whatever may be our wishes, our inclinations, or the dictates of our passions, they cannot alter the state of facts and evidence."

I will note that Adams uttered that quotation from a courtroom floor. In 1770, a unit of British soldiers killed five people in the streets of Boston; it was a massacre. Afterwards, the city was out for blood. And the soldiers were likely to be hung. But Adams stepped into the breach and volunteered to represent the soldiers in court. He was scorned for this decision. He was called a traitor. Adams nonetheless insisted that the dictates of passion and politics cannot and should not trump evidence and truth.

In the end, the soldiers were acquitted and the rest, as they say, is history. But Adams was right. Facts are stubborn things, and we should stand up for them even if every disciplinary bone in our body pushes us to remain silent and above the fray. This might sound like a call to resistance to some. But when a call to reason is a call to resistance, that only confirms the sorry state of our politics. In usual times, we take care to remain inside the bounds of university life, worried about venturing too far into the world lest we lose our critical distance. But sometimes we need to do more. This conversation is happening with or without us. Do not let it happen without us.

Universities have always been places that strike the balance between arguments and truth. They are one of the few remaining spaces where we can question everything and still believe in something. Where everyone has the right to speak but where we reserve the right to condemn something as wrong. Now is the time to protect those spaces, to insist on their importance, even if it requires us to take up an unaccustomed role of speaking out.

Just as my profession, trained not to believe in anything, has long stood up for the rule of law, so should we remind the world that even if we disagree about truth, we still believe in it. Facts are stubborn things, and so are we.

Jane Mayer

Jane Mayer has been a staff writer for The New Yorker since 1995. She was elected a Fellow of the American Academy in 2017.

Falsehoods uttered by politicians are, of course, nothing new. What is new is the amplification of these lies by new forms of social media. Overtly partisan, frequently false, and often viciously personal attacks are now spread virally and unfiltered by countless waves of trolls, bots, phony think-tank bloggers, junk scientists, and even for-hire opposition researchers.

I am so happy to be able to join you all here today. I was going to say that I am honored, but I am more than honored. After hearing of the other new Members' accomplishments, I am blown away to be in the company of so many esteemed people. So before anything else, I just want to say thank you for welcoming me into the Academy, and for asking me to speak on behalf of my Class.

My introduction to the Academy's president, Dr. Jonathan Fanton, actually began quite some time ago. Approximately forty years ago I had the pleasure of being taught in a small, undergraduate seminar at Yale University by Professor Fanton. The seminar was quite specialized and unusual. Its focus was to examine, in as rigorous a way as possible, how and why several momentous decisions in American history were made and assess whether these decisions had been wise. My particular focus was on how America decided to drop the atomic bombs on Hiroshima and Nagasaki on August 6 and 9, 1945.

All these years later, I can no longer remember what my own inexpert undergraduate assessment was as to whether mankind's first and hopefully last use of atomic weapons was justified. But what I do remember, and have carried with me throughout the rest of my life, is my introduction to the timeless methodology of scholarship, which included approaching the subject with an open mind and searching relentlessly like an obsessed amateur sleuth for every available scrap of evidence – including reading the personal diary of Henry Lewis Stimson, President Truman's Secretary of War, despite his admonition that "Gentlemen do not read other each other's mail" – let alone their diaries! We pored over every relevant document we could find, and all manner of primary and secondary sources, grappled with gaps and contradictions, formed hypotheses, argued and tested them on each other, synthesized each others' critical thinking, and finally arrived at what Carl Bernstein, one of the greatest investigative journalists of our era, calls "the best obtainable version of the truth."

This has basically been the same evidence-based process I have tried to employ in pursuit of the truth as a journalist ever since. And it is, I would guess, the same methodology that most of you in both the humanities and the sciences employ in your work every day. It is the methodology that we have inherited from the Enlightenment, passed down through the generations, and that has contributed to all manner of breakthrough and progress in human history. But unfortunately it is an approach to scholarship that I fear is under political assault today, in both the humanities and the sciences.

It may seem a stretch to lump these two disciplines in together. In 1959, C. P. Snow famously gave his Rede Lecture about the vast chasm of understanding that divided the two cultures of science and the humanities. Today, I would argue that they are less divided than united in their pursuit of fact-based truth against a common threat, which for lack of a better phrase was best described by Kellyanne Conway, the counselor to President Donald Trump, as the production of "alternative facts." You may remember that at the time that Conway uttered this phrase, she was arguing that despite demonstrable, photographic proof, Trump's inaugural crowd was larger than that of his predecessor, because the president – and his dutiful press secretary – had said this was so. Although the dispute at hand was small and petty, the skirmish represented a much bigger and more prophetic clash. As our fellow Member of the American Academy of Arts and Sciences and

my longtime friend Jill Abramson succinctly responded, "Alternative Facts Are Lies."

The fib about the size of the inaugural crowd was only the start. There have been many more, and much worse ones from the current administration. *The New York Times* has kept a running tally that lengthens almost daily, and fact checking has become a cottage industry, one of the few growth areas, perhaps, in the journalism field. Moreover, it is not just our current crop of political leaders at home who are waging this battle. Similar attacks have been launched on the truth, and those who tell it, by regimes around the world.

At home, of course, these attacks have included an effort to undermine the credibility of the independent mainstream news media as "fake news," and those who write it as "Enemies of the American People." But the targets range far beyond mere journalists. All manner of independent, fact-based research has come under attack, ranging from the economic analyses by the non-partisan Congressional Budget Office to research done by the National Oceanic and Atmospheric Administration. Among the most worrisome of these attacks, actually, have been those on the scientific community in general, and on the science of climate change in particular, which President Trump memorably denounced during the 2016 campaign as a "hoax" perpetrated by the Chinese.

Falsehoods uttered by politicians are, of course, nothing new. What is new, however, is the amplification of these lies by new forms of social media. Overtly partisan, frequently false, and often viciously personal attacks are now spread virally and unfiltered by countless waves of trolls, bots, phony think-tank bloggers, junk scientists, and even for-hire opposition researchers, who literally stalk and "track" opponents with video cameras in search of compromising material that they can then post, as happened this year to the environmental activist Bill McKibben.

It is apparently apocryphal – an early form of fake news evidently – that Mark Twain ever said that "a lie goes halfway around the world before the truth pulls its boots on," but whatever the derivation today, a lie can spread not just halfway around the world, but entirely around the globe, in minutes, and often the truth stands almost no chance of completely catching up.

As a result, large swaths of the population are being purposefully and constantly misled. Social media, especially Facebook, can circulate false information to two billion people each day. We now know that virally spread fake news helped defeat Hillary Clinton in our last presidential election, an unprecedented infection of our democracy. And any crackpot organization can now use the same tools to distribute fake information to so-called like-minded people. The careful research of scholars and scrupulous investigative work of journalists can be overpowered by a handful of keyboard clicks. A technology that holds the great promise of connecting people also has great destructive power to misinform and divide them. Humanity has never before had an instant, information distribution technology of such force – it has been compared to the seismic impact of Gutenberg.

Our political system is reeling from the blow. Charlie Sykes, the former right-wing radio talk show host, has described the fallout well: "The cumulative effect of the attacks" on fact-based media, he has said, has been "to delegitimize those outlets, and essentially destroy much of the Right's immunity to false information." He added, "All administrations lie, but what we are seeing here is an attack on credibility itself."

It seems unthinkable, as we are celebrating the incredible achievements of this year's Nobel laureates in science, that not just the news media but whole branches of science could be under attack, too, but sadly they are. As Paul Krugman, the Nobel Prize – winning economist and liberal *New York Times* columnist, put it, "In the Trump era we are ruled by people who are completely alienated not just from climate science, but from the scientific idea itself . . . the notion that objective assessment of evidence is the way to understand the world." He has called this "willful ignorance" "deeply frightening," and has worried that it may end up undermining our democracy and "destroying civilization."

At an upbeat occasion such as this one here today, I do not want to end on such a pessimistic note. So instead I will leave you with a thought, a kind of inchoate action plan at this worrisome moment, derived from my own experience in these culture wars. In 2010, after *The New Yorker* published my long and carefully researched investigative report on the outsized political influence exerted by two billionaire brothers, Charles and David Koch, they were unable to identify any errors, but nonetheless they hired a private investigator to dig up dirt on me personally, in hopes of undermining my credibility. It was, in other words, a page out of the current playbook that we are seeing all too often. If anyone had believed their attack, it could have been professionally devastating. But instead what happened was that several colleagues of mine jumped into the fray, and publicly defended my work and my integrity. They did so quickly and generously, even though this wasn't their fight. But they did it, I think, partly because they sensed that this is all of our fight. So I hope that all of you will keep doing and honoring each other's astonishingly fine work, and that when honest, evidence-based truth or those who tell it are attacked, you too will jump into the fray, speak up, and have each others' backs, because whether we are in the humanities, the arts, or the sciences, this is actually all of our fight.

Gerald Chan

Gerald Chan is the Co-Founder of Morningside, a private investment group with venture capital, private equity, and property investments. He was elected a Fellow of the American Academy in 2017.

The answer to reversing the decline in life expectancy is not a further increase in healthcare expenditure. I submit that the answer lies in education, which is one of the strongest positive determinants of life expectancy. It is an investment in the future.

Whereas each of the Academy's Classes I through IV consists of individuals in coherent fields of scholarship, Class V is a diverse collection of people in business, education, public affairs, philanthropy, journalism, and more. As I am to speak on behalf of this medley of distinguished women and men, I can only do justice to the diversity by speaking on something that is of sufficient generality. I shall begin with life and time.

Axiomatic to all biological life forms is that life is bounded by time. We celebrate birthdays year after year to remember the beginning of life and to mark the progression of time. For a young person, this progression means growth, but past a certain inflection point, this progression equates to inching ever closer toward a terminus. The most primal assessment of a person's life is simply how long did he live. I am cognizant of this conjuncture of life and time because much of what I do in biotechnology can be characterized as being in the business of giving life more time. Sometimes we succeed in bringing people back from the verge of expiration. Other times, the best we can do is to effect some form of disease modification and offer the patient an extended interregnum somewhere between life and death.

I remember when my grandmother turned sixty, I thought she was really old. My childish perception was not too wrong because statistically, she could expect no more than another decade of life. At the dawn of the twentieth century, the life expectancy of an American person was forty-seven years. At the close of the century, that life expectancy had climbed to seventy-seven years. Within the century that saw two world wars fought with ever more deadly weapons of mass destruction, humanity has also made great strides in the direction of beneficence.

Recent data, however, have called into question whether the success of this life extension project can continue *ad infinitum*. Two years ago, the world was stunned by a paper published by Anne Case and Angus Deaton (I should note that Anne is also being inducted into the Academy today) that showed that since 1999, death rates have been climbing among middle age, white non-Hispanics in this country. This phenomenon was not observed for comparable cohorts either from other ethnic groups in this country or from other developed countries in the world. More granular examination of the data reveals that this phenomenon was most pronounced for the less educated and that the leading causes of death were drug overdose, suicide, and cirrhotic diseases of the liver resulting from alcohol consumption or viral infection. Geographically, the phenomenon was particularly pronounced in rural America and in former industrial towns now left behind by a new economy powered by technology and globalization.

These data speak to the grip of social determinants on population health and life expectancy. Indeed, the earlier works of Sir Michael Marmot and others from the United Kingdom have shown a tight correlation between income and life expectancy. For example, Marmot followed a train line across the city of Glasgow in Scotland and showed that with every stop, income level dropped and life expectancy dropped in lockstep. He then repeated the study along a train line from Montgomery County in Maryland to Washington, D.C., and saw the same concordance. For every one and a half miles along the railroad track, life expectancy declined by one year.

Such population health data are a glaring reflection of social conditions. The study by Case and Deaton reveals that in parts of America, people are dying the "death of despair" at an alarming rate. In a connected society, it is simply not possible that the plight of this dispossessed population will not be felt by all even though they may live in small towns and we live in prosperous

metropolises like Boston. History shows that at a certain point, the dispossessed will radicalize the polity whether it be effected through violence or through the ballot box. Signs of this were clearly evident in the voting pattern of last November's election. What happened in Charlottesville, Virginia, this past summer will happen again as long as the same social conditions persist and irrespective of whether statues of Confederate leaders remain on public display. When the present is so unpalatable and offers no hope for the future, people will engage in a rabid pursuit of a vanished past or, worse yet, an imagined past.

The answer to reversing the decline in life expectancy is not a further increase in healthcare expenditure. America already spends 18 percent of its GDP in healthcare and yet the life expectancy of the American people is inferior to many nations that spend far lower percentages of their GDP on healthcare. We have long passed the point of diminishing return.

I submit that the answer lies in education, which is one of the strongest positive determinants of life expectancy. It is baffling to me that year after year, healthcare expenditure grows in this country while the public-sector budget dedicated to education shrinks. Witness the finances of the great state universities in this country. When I talk to my friends at UC Berkeley, I get the sense that the neglect by the politicians in Sacramento has the effect of dismantling that great university brick by brick.

Healthcare expenditure is an expenditure for the benefit of the present generation. Considering that the consumption of healthcare is weighted heavily in the latter years of people's lives, including especially end-of-life care, it may be said that such expenditures represent an attempt in stretching the past. Education, on the other hand, is what we give to the young. It is an investment in the future. If we accept that resources are finite and that debts will have to be repaid, spending on the past or the present cannot but be at the expense of the future. Between the past, the present, and the future, there are hard choices – moral choices – that our society can no longer afford to sidestep.

If I am being recognized today for my philanthropic work, I would like to note that for me, philanthropy is a voluntary departure from a rights-based rubric of how one relates to his fellow men to one that has its source in duty, empathy, community, an exalted view of man, and an abiding commitment to the dignity of all. As much as we cherish rights, some natural and unalienable, over-assertion of rights does have untoward consequences. For the individual, it leads to narcissism, disregard for history and posterity, and will produce an atomized and alienated person. For society, it accentuates differences and risks social fragmentation and eventually the breakdown of society. Such are the perils facing our nation today.

In 1780, this Academy was founded explicitly with the future of the nation in view. John Adams, one of the Academy's founders, once wrote to his wife Abigail, "Posterity, you will never know how much it cost the present generation to preserve your freedom." It is only right that each generation should make sacrifices for the good of its children.

I recently attended a concert of Czech music in which I heard these lyrics:

Lord God, our Father

Turn your eyes on the multitudes,

Whose hands clasped in prayer
reached for the weapons

In order to create bread for their
children out of blood.

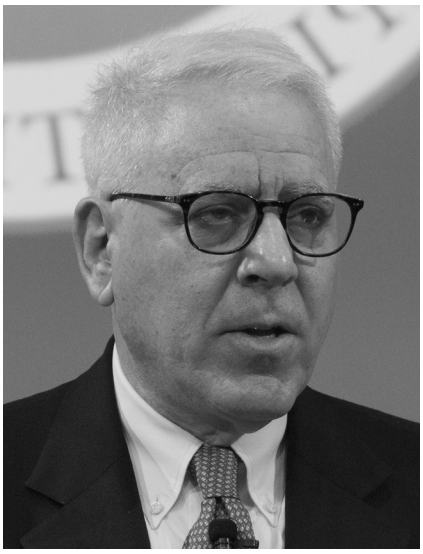
It is with this concern for posterity that we are being called to the Academy today. It is a calling to share in the stewardship of this country's future. The American Experiment is as yet unfinished even though the American Century, in the lifetime of we the Baby Boomers, has come and gone. We press forward, still affirming that this is a nation conceived in liberty and dedicated to the proposition that all men are created equal. ■

To view or listen to the presentations, visit https://www.amacad.org/induction2017.

Annual David M. Rubenstein Lecture

Looking at Earth: An Astronaut's Journey

On October 8, 2017, as part of the Academy's 2017 Induction weekend, **Kathryn D. Sullivan** (Ambassador at Large at the Smithsonian Institution's National Air and Space Museum; former NASA astronaut; and former Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator) discussed her experiences as a NASA astronaut and participated in a conversation with **David M. Rubenstein** (Co-Founder and Co-CEO of The Carlyle Group and Chairman of the Board of Trustees of the Smithsonian Institution). The program, which served as the Academy's 2059th Stated Meeting, was the inaugural Annual David M. Rubenstein Lecture. An edited version of the presentations and discussion appears below.



David M. Rubenstein

David M. Rubenstein is Co-Founder and Co-CEO of The Carlyle Group. He is Chairman of the Boards of Trustees of the John F. Kennedy Center for the Performing Arts, the Smithsonian Institution, and the Council on Foreign Relations. He was elected a Fellow of the American Academy in 2013.

In my view, the scientific and technological innovation that most captured the public's attention was flight and, ultimately, flight around the earth and into the cosmos.

It is difficult to identify the single most important scientific or technological development of the twentieth century. You could say the theory of relativity, or the discovery of DNA, or the development of vaccines, or the creation of the Internet. In my view, the scientific and technological innovation that most captured the public's attention was flight and, ultimately, flight around the earth and into the cosmos.

If we think about it, the Wright brothers' work in Kitty Hawk received an enormous amount of attention. People around the world were amazed that a person could fly, because for most of human history the idea of getting into space was something almost nobody had thought was realistic.

Homo sapiens have been around for roughly two hundred thousand years. For most of that time, people have looked up and wondered where the stars come from, where the sun comes from, where the moon comes from, and could we ever get closer to any of them. Could we ever get off the ground? For 99.9 percent of our history, we could not.

Then the Wright brothers proved we could get off the ground. And after that, Lindbergh flew from the United States to Paris. As we developed more and better equipment, Chuck Yeager and others achieved supersonic flight, and interest in getting off the ground continued to increase. Then the Cold War came, and we were in a competition with the Russians over who was going to be the superior party in space. Many of you may remember when the first Russian Sputnik went up in 1957. We were worried that our country was falling behind. In 1958, President Eisenhower signed legislation to create NASA, which was to be our counter to the Russian program.

Eventually, we put our own satellites in space, and then we put our first man in space: Alan Shepard. His was just a 15-minute flight, but it received an enormous amount of attention. And then in 1962 John Glenn circled the globe three times.

After that we began the effort to go to the moon. President Kennedy set the goal: By the end of the 1960s, a man would go to the moon and come back safely. Although Kennedy did not live to see it, in 1969 Neil Armstrong landed on the moon. We then began to see other extraordinary things. We had space shuttles and the international space station, and we started to explore the cosmos in new ways. We learned so much more about space. The importance of this great advancement was not just that we could circle the globe but that we could learn much more about the globe. As a result of our exploration, we now have many more technological and scientific skills. So

President Kennedy set the goal: By the end of the 1960s, a man would go to the moon and come back safely.

much of what our life depends on today – such as the National Weather Service, the global positioning system, cell phones, and modern computers – came about as a result of our efforts to explore space. One of the heroes of that space exploration is with us today: Kathryn Sullivan.

In 1978, Kathryn was in the first class of women selected by NASA to become astronauts. Before then, no women had been allowed. Why? Well, an astronaut had to be a fighter pilot or a test pilot, and women were not allowed to be fighter pilots or test pilots.

Kathryn's fellow classmate, Sally Ride, was the first American woman in space, but Kathryn was the first American woman to do an extravehicular spacewalk. In all, she served on three shuttle missions, once each aboard the space shuttles *Challenger*, *Discovery*, and *Atlantis*, spending about 530 hours in space – an extraordinary amount of time – but she has done so much more than that.

In addition to her time as an astronaut, Kathryn has had an outstanding career as a scientist. She attended college at the University of California, Santa Cruz, and received a Ph.D. in geology from Dalhousie University in Halifax, Canada. She was then selected as an astronaut by NASA and served as an astronaut from 1978 until 1993. When she left NASA, she became the chief scientist for the National Oceanographic and Atmospheric Administration (NOAA). When that service ended, she went to Ohio, where she headed the Center of Science & Industry, a science museum in Columbus. Later, she went to work at the John Glenn School of Public Affairs at Ohio State University. In 2011, President Obama appointed her Assistant Secretary of Commerce for Environmental Observation and Prediction and Deputy Administrator of NOAA. In 2014, the president appointed her Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator.

Today, she is writing a book about her experiences helping to deploy the Hubble Space Telescope on her spaceflight aboard the space shuttle *Discovery*. She has also been involved with the Smithsonian Institution's National Air and Space Museum, holding the Charles A. Lindbergh Chair in Aerospace History and now serving as an Ambassador at Large for the museum.

Kathryn has an extensive background in science, an extensive background in public affairs, and the terrific experience of serving as an astronaut and helping our country advance greatly in science. It is my honor to introduce Kathryn Sullivan.

Kathryn D. Sullivan

Kathryn D. Sullivan is an oceanographer and astronaut and the first American woman to walk in space. She is former Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator. She is currently a Senior Fellow at the Potomac Institute and an Ambassador at Large for the Smithsonian Institution's National Air and Space Museum. She was elected a Fellow of the American Academy in 2017.

While in space, you go around the earth in 90 minutes. If you are up for long enough, you get to watch the seasons change beneath you, you can watch the planet breathe beneath you and see the vegetation bands move.

I would like to share with you a few glimpses of what the adventure of living and working in space is like, and then I want to shift gears and consider the remarkable perspective that living in the space age gives us.

Let's go for a ride, starting on the launch pad of the space shuttle *Discovery*. Water is spraying out the back end because a bomb is about to go off, and we want to suppress the noise and the vibrations. One-and-a-half million pounds of thrust is coming up to speed, to be followed by the explosion of five million additional pounds of thrust. If you didn't understand before that you were riding a bomb for a living, you understand it vividly at this moment.

This journey is zero to 17,500 miles per hour in eight and a half minutes. Every minute, you are going about 2,000 miles per hour faster than you were before. In less than 30 seconds, you are passing the altitude of every jetliner. Then you pitch the vehicle over and accelerate until you are at that 17,500-miles-per-hour speed.

It is a smooth ride for much of the journey. It is like a push on the back of your chair then the engines cut off and you are in this magical environment where you can swim at will throughout the cabin. The force of a fingertip will move you or a 300-pound space suit or one of your colleagues anywhere through the environment.

I made a habit of always eating my dinner up at what is normally the ceiling, dangling downward simply because I could. This is the only place my mother would forgive me for playing with my food.

Up here you are your own clean-up crew, of course, so if you lose an M&M, if it wanders off somewhere, it is important that you know how the airflow circulates through the vehicle and where the dead spots are, because the stray M&Ms and lost socks and other things will be right there in about half a day, and you can go scavenge them. If you think M&Ms are fun, Pepperidge Farm goldfish will display schooling behavior in this environment.

Another very fun thing is how quickly people change their vocabulary. If you wanted me to give you a hand control or a remote, in short order you would find you had ceased saying, "Would you please pass me the remote?" or "Please pass me the M&Ms?" Instead you would say, "Would you please send me . . . ," and you just give the object a little shove and it cruises across the cabin. It becomes a natural way of doing things, and after ten days (that was the length of my longest flight), it is hard to remember that when you get back to Earth this isn't going to work anymore.

Playing with water is even better. On the space shuttles, where there is not much room, a favorite sport was to make a ball about the size of a golf ball, preferably out of your orange drink so you could see it, and then play air hockey with it by blowing on it until it was drifting toward your opponent. The crewmate would have to blow it back with just the right amount of force. If you fail to get the vectors exactly right, instead of hydrostatic forces winning and keeping the liquid in a nice little ball, surface tension will take over, and you are either going to drink or wear the water ball. This makes hair washing and hygiene very interesting.

While in space, you go around the earth in 90 minutes. On two of my flights, our orbit was inclined to the equator 57 degrees, so we saw a substantial swath of the surface of the earth. If you are up for long enough – which, regrettably, I was not – you get to watch the seasons change beneath you, you can watch the planet breathe beneath you and see the vegetation bands move.

The scenes are stunning. Every time you look out the window, you are seeing about a thousand-mile swath: full continents are out your office window at every glance;

history is just out your window. The cavalcade of voices and the kaleidoscope of impressions and recollections that come forth from your fellow astronauts are stunning. Yet the first thing said by every astronaut is usually, "Holy cow, look at that. It looks just like the maps!"

Sometimes, it is just plain modern art – the center pivot irrigation of the U.S. Great Plains, with a quick seasonal dusting of snow and a low sun angle popping everything into great relief. The images could hang in the Museum of Modern Art. No one would know the difference.

Sun glint does magical things anywhere you see it on water. Here, a very low sun right near the terminator view of the mouth of the Amazon reveals the endless braiding, the intertwined swamps and lowlands, and the river making its channel and jumping back and forth however it wishes in the massively flooded delta.

At night, the earth is stunning in altogether different ways. The geophysics really stand out. You can see where the magnetic field lines curve down toward the surface of the earth, and you notice something that most of us don't think about routinely. The same physics that make the aurora at the poles are actually happening about 60 to 100 kilometers above the earth, all around the earth, and all the time. It just needs to be dark so we can see it.

One of the other magical things about seeing our planet from this perspective – in space, going 17,500 miles per hour, a lap around the planet every 90 minutes – is that you get 16 sunrises and 16 sunsets every 24-hour period. The sun comes up or goes down every 45 minutes whether you need it to or not. Whether you think it's bedtime or not, it's happening, and at each of those junctures you have these extraordinary opportunities to see the prismatic effect of our atmosphere edge-on, backlit by the sun.

Modern-day satellites actually take advantage of this to measure the chemistry and the properties of the planetary atmospheres as well as our own atmosphere. In space you see the fine layering of the atmosphere. You are seeing all the way up to the tropopause and the stratopause, and far up into the ionosphere. You see the intricate layering that creates the physical envelope that retains our atmosphere and water vapor, which makes this planet a lushly habitable little ball. It's spectacular and endlessly fascinating to see it revealed in this fashion time and time again through the course of a day.

The Apollo crews competed to get the best earthrise picture. Frank Borman's was the iconic shot that is cited as the one where the scales fell from our eyes, the one that gave us the first sense of ourselves as flying on this little blue dot.

One of the other magical things about seeing our planet in space – going 17,500 miles per hour, a lap around the planet every 90 minutes – is that you get 16 sunrises and 16 sunsets every 24-hour period.

Nowadays we live with similar all-at-once views of Earth every day of our lives and in ways we don't think about because it is the space age. This is the vantage point of satellites, whether they are orbiting our moon or orbiting closer by. Mankind's ability to live and operate and observe our planet from orbit has made it possible, for the first time in human history, to take a snapshot of conditions across the entire globe at once.

With satellites, we have the ability to measure the state of water vapor in the atmosphere of the entire Western Hemisphere or the surface temperature of the ocean. The ability to take a snapshot at one point in time, coupled with modern-day computing and the knowledge of the physical processes of our planet that has been gained over decades of fundamental research, has made it possible for us to foresee what is coming in the natural systems of our planet.

Satellites are making these measurements all the time. On a moment-by-moment, day-in-by-day-out basis, they are measuring infrared radiances, microwave radiances, GPS radio occultation – the kinds of fundamental physical measurements we know how to transform into physical properties of our planet. This is what makes it possible to have a global understanding of our Earth.

From space we can see the biosphere. We see plankton blooms in the ocean. We see the land greening and going fallow as the seasons change. We see the circulation of precipitable water, the potential for rain in the atmosphere. We see global wind fields all at once, across the whole planet.

The ability to take the pulse of the planet and then propagate that forward based on the fundamentals of physics underlies everything from your daily weather forecast to climate outlooks to the kinds of weather and climate signals that are factored into crop futures and the insurance and reinsurance markets. It's what we came to call in my time at NOAA as "environmental intelligence": actionable, timely information that is pertinent to decisions that real-world people are making in their homes, in businesses, in governments around the globe.

We don't think any more about how extraordinary it is to be the first generation of human beings with this capability. We are

In space, you see the fine layering of the atmosphere. You see the intricate layering that creates the physical envelope that retains our atmosphere and water vapor, which makes this planet a lushly habitable little ball.

really still just infants at understanding and appreciating how to bring this information into our decision-making, into our public and private lives, in ways that can help us live more wisely and more well on this precious little planet of ours.

About ten days ago, the spacecraft *Cassini* plunged into the atmosphere of Saturn. Its grand finale was to fall between the rings and the planet, but one of the other really remarkable things *Cassini* did was to flip its telescope around to us and help us appreciate place and scale and perspective in the solar system. It photographed Saturn from the other side, backlit by the sun, and we are all in that picture on the little blue dot that is Earth.

I never saw Earth from this far away, but even from the vantage point I had when circling our glorious beach ball several hundred times, it is a magical, fascinating, powerful, and also fragile and precious place. My passion, the reason I applied to be an astronaut, was that I knew, if I magically somehow got in, I would get to see the earth with my own eyes from that vantage point. Earth is what motivated me to go into space. What motivated me to leave my space-faring career and come back to Earth was the passion and commitment to make the space perspective matter, to transform our understanding into useful knowledge, and put it to good practice in the interest of improving life on Earth.

Discussion

David Rubenstein

You have been an administrator in Washington dealing with members of Congress and you have been an astronaut. Which role has been more taxing, either physically or mentally?

Kathryn Sullivan

Working with Congress is definitely more taxing. But each role is intriguing in its own way, like different jigsaw puzzles that need to be solved.

David Rubenstein

When you told your parents, "I'm going to go be an astronaut," what did they say?

Kathryn Sullivan

I remember that phone call very well. I had just learned from NASA that I had made the final cut to be interviewed, which meant 8,700 candidates had been cut down to 200. There was about a factor of 10 still to be cut, but I had made the shortlist. I rang my parents and excitedly said, "I'm going to get interviewed." My mother said, "So what does this mean?" If NASA didn't pan out, I had a postdoc in hand that would have me diving to the bottom of the seafloor in Alvin submersibles to study the geology of mid-ocean rifts. So I glibly said, "Well, it means I'm either going 200 miles up or 4,000 feet down." There was a pained pause on the phone, and then my mom said, "Isn't there anything exciting on the surface?" She called back the next day to retract that comment, by the way, and to tell me I had her full support because she would want her mother's full support if she had those kinds of adventures before her. So here's to you, Mom!

David Rubenstein

What type of training do you have to go through to be an astronaut?

Kathryn Sullivan

The qualifications include advanced degrees or proven skills, preferably with some operational bent that lets NASA see how you respond in unforeseen circumstances when the stakes are high and decisions are crucial. Once you are in, there is about a yearlong curriculum tailored by NASA. It is essentially graduate school for astronauts, and includes any technical subject you can imagine that touches spaceflight: physiology, solar physics, meteorology, spacecraft engineering, guidance and flight control. You end up taking a combined first- and second-year graduate course in all of those subjects.

David Rubenstein

Three Mercury astronauts were killed in their spacecraft – before they got off the ground – so clearly there is the potential of losing your life. Did you ever worry about that?

Kathryn Sullivan

I worried about it most intensely before I even filled out the application. I figured if you get into something like this you should think through for yourself beforehand what the risk-reward equation is for you, for the country, for mankind, at whatever levels matter to you. The risk will never be zero. It is a human undertaking. People make errors of omission and commission, so I really thought that through.

By the way, I was applying in the 1970s when there was a fair bit of controversy. "Why are we throwing all this money at

space things? We have problems here on Earth." I thought about those criticisms, too, to decide if I was aligned with them or if I thought this was something worth doing.

David Rubenstein
Your astronaut class had six women?

Kathryn Sullivan
Six women, three African American men, and an Asian American man. We called ourselves – and the white guys came up with this – 10 interesting people.

David Rubenstein
When you are in training, do you have to pretend that you think the men are better than the women, or did you really know the women were better than the men?

Kathryn Sullivan
I knew we each had to hold our own. I need each of my crewmates – male, female, black, green, or otherwise – to know their stuff, to be completely competent and hold their ground when things get crazy or squirrely or scary. And they need to be able to trust me as well.

David Rubenstein
As you know, sometimes people don't get along with each other, and sometimes they don't talk to each other or don't want to meet with each other. When you are in space, you can't really do that, right? So how do you deal with human problems?

Kathryn Sullivan
Shuttle missions are sprints. They are five- to ten-day missions, and NASA at that time paid scant attention to those factors. They put a particular five on a crew because they needed their skills, and they didn't particularly care if the five loved each other. They just needed their combined skills to get certain things done. The message was, "We need you to be ready to deal with the unexpected. If you never want to talk to each other again when you get back, we don't mind. If you become best friends when you're back, more the better."

Earth is what motivated me to go into space. What motivated me to leave my space-faring career and come back to Earth was the passion and commitment to make the space perspective matter, to transform our understanding into useful knowledge, and put it to good practice in the interest of improving life on Earth.

The International Space Station is different. You can't run people on a six-month timeline at that kind of cadence, so more care is taken with profiling, to getting some understanding of personality matches, and to talking things through in advance.

David Rubenstein
So, you are sitting there in Cape Canaveral, in the *Challenger*, ready to be launched. How many people were on that flight?

Kathryn Sullivan
There were seven on that flight.

David Rubenstein
As you are sitting there and the countdown is approaching, do you think about whether the shuttle is going to blow up? Does your heart rate go up?

Kathryn Sullivan
You sit there for a couple of hours while a thousand and one checks are being done. I actually took naps through that time.

David Rubenstein
You napped?

Kathryn Sullivan
Yes. In eight and a half minutes, it's going to get really busy, so you catch what final naps you can.

David Rubenstein
At what point do you realize the launch is going to be successful? When you are one minute into it, two minutes into it?

Kathryn Sullivan
You realize it is successful when you have landed and stepped off the spacecraft in one piece. For everything in between, you are paying very close attention.

David Rubenstein
Let me ask you the question most children must ask you right away: How do you go to the bathroom?

Kathryn Sullivan
Ah, yes. The grownups are always really grateful when children ask about this because they have all been wondering but are too sheepish to ask. The cute answer is, "Just like you do here but much more carefully and with a checklist, because your mistakes will follow you around."

We all know what happens on Earth, where gravity helps. But in zero gravity how do I make the waste coming out of my body go where I want it to go? The answer is air-

In my judgment, there is worth in this pursuit of the frontier – both direct human exploration and robotic exploration.

flow. A space toilet pulls some of the cabin air through the gap between the toilet seat and your rear end, and that entrains both the liquid and the solid.

David Rubenstein
When you have men and women in the shuttle, is there any privacy, or do you forget about that in space?

Kathryn Sullivan
There is not a lot of privacy. Each crew would handle it a little differently. I was one of two women on my first crew and the only woman on my other two flights. An ethos just developed between us, that worked male or female. Someone would say, "I'm going to change my skivvies" or "I'm going to change my shirt," and the rest of the group would respect this sort of courteous blind zone.

David Rubenstein
What about the food? Do astronauts really drink Tang? I always drank it because I thought the astronauts did.

Kathryn Sullivan
Well Tang had really good marketing. The current version of Tang is astronaut ice cream, which I promise you has never been in a spaceship. The food is okay. I can have great food when I am back home for most of the rest of my life. So, if you are going to serve me mountaineers' food or camping food for ten days or even a couple of months, I can handle that.

David Rubenstein
What about special treats? Do they give you anything special to make you feel better?

Kathryn Sullivan
You get a fair bit of personal choice over what is in the pantry and what is on your menu, and there is astronaut lore about favorite items.

David Rubenstein
What about sleeping? Where are the beds? How do you sleep?

Kathryn Sullivan
On two of my flights we all slept during the same cycle and just turned everything over to the ground for monitoring. Some folks would zip up in a little sleeping bag, which could be tied off on a wall or just dangle on a string. I tended to sleep on the upper deck and almost float free. I would take an eyeglass tether about the size of a microphone cord and loop it through my watch and tie it through a little eyelet on the instrument panel and just be floating off the end of that.

David Rubenstein
You can sleep six hours like that?

Kathryn Sullivan
Yes. You look like you are in a dead man's float. Your body goes to this neutral posture. More than one astronaut has woken up in the middle of the night and seen a pair of hands up there and thought someone was coming at them until they realized, "Oh, those would be *my* hands." By the way, nobody snores in zero gravity.

David Rubenstein
Oh, really? Wow. What about flirtation? In zero gravity, is there any flirtation between the men and the women?

Kathryn Sullivan
On the short flights I was on, there certainly wasn't. What may happen on the space station, I don't know.

David Rubenstein
On your first spaceflight you did an EVA, an extravehicular spacewalk. You were out there for about four hours, tethered. What were you doing?

Kathryn Sullivan
We had an engineering test to do. NASA and the Air Force were interested in proving whether satellites could be refueled in orbit. That sounds like a trivial thing, but the loss of fuel in a satellite is often what ends the life of the satellite. Unlike your car, where access to the gas tank is a simple screw top, a satellite's fuel system usually has three caps and four sets of safety wire and a few other things on the valve to make extra sure nothing gets out. In addition, the propellant is both highly explosive and very toxic, so we had a specially designed set of tools to protect us from the toxic propellant once we removed all of the caps and seals.

David Rubenstein
So, when you are putting on your space suit to go outside, how long does it take to get that space suit on?

Kathryn Sullivan
To get outside, the total process, assuming you set everything up and staged it the day before, takes four hours.

David Rubenstein
Four hours to put the space suit on?

Kathryn Sullivan
No, four hours to get ready to go outside. An hour of that is physiology: sealing yourself in the suit, which is pure oxygen at low pressure and letting the nitrogen in your blood-

stream slowly wash out. You face the same risk as a scuba diver. You are going from a 10.2 psi cabin, which is about the pressure of, say, Copper Mountain, Colorado, to 4 psi pure O_2. Because of the decrease in pressure and the pure oxygen environment, all the nitrogen in your bloodstream wants to get out, and that can give you the bends.

David Rubenstein
When you go outside, are you tethered?

Kathryn Sullivan
Yes.

David Rubenstein
Suppose you were untethered. What happens then?

Kathryn Sullivan
If I undo my tether and let go of the handhold, nothing happens. I am still in formation. I am flying in formation with the spacecraft because I am doing 17,500 miles per hour just like the spaceship. If I let go of the spaceship, there is no air that suddenly blows on me and slows me down.

If I was clumsy when I let go and brushed against the spaceship, then I would be doing 17,500 miles per hour but in a slightly different direction from the spaceship. As soon as that handrail got just past my fingertip, I am never grabbing it again unless I have some propulsion to push me back or the spaceship maneuvers toward me.

David Rubenstein
Have there been untethered spacewalks?

Kathryn Sullivan
Yes, in a handful of spacewalks the astronauts were wearing jet packs that let them maneuver.

David Rubenstein
Can you explain the physics of this? You are going 17,500 miles per hour. When you are untethered, why are you going at that same speed? Since you are not a spaceship, why doesn't the spaceship just move away and leave you hanging there?

Kathryn Sullivan
If we apply the basic principles of physics to this situation, I am in the same energy state as the spaceship, coasting through space at 17,500 miles per hour. All I did was physically uncouple from the spaceship, but nothing else has been done to change my energy state. I didn't slow myself down or speed myself up, and the spaceship isn't firing its engines. So, I am still right there at the same energy state as the spacecraft. And there is no drag.

Hubble was designed to be maintainable in orbit, and one of the tasks we had as the deployment crew was to make sure it had all the tools and all the procedures it needed, and we checked them on the telescope. We had to guarantee they worked.

Think about when you hold a candy wrapper out the window of your car: it is doing the same speed you are. When you let it go, the reason it falls behind you is that gravity pulls it down. The force of gravity acts on it, and the drag of the air acts on it even if you are at a constant speed going forward. But neither of those forces is active when I let go of the spaceship.

David Rubenstein
So you finish your walk. You go back in. At that point, how much longer are you on the space shuttle before you land?

Kathryn Sullivan
My spacewalk was on October 11, and we deorbited on October 13, so we had a day to button everything up and get ready to return.

David Rubenstein
When you land, is there any fear that you are going to burn up coming back in?

Kathryn Sullivan
Yes. That is what happened with *Columbia*. If you come in at too shallow an angle, you can bounce off the atmosphere. Then you might not have enough propellant to do another slowdown, and you will be trapped in orbit. If you come in too steeply, and the heating rate is too high, the vehicle burns up. You have to thread a fine cone on reentry.

David Rubenstein
About a year and a half after your mission on *Challenger*, it exploded on liftoff. You knew the people who were on that flight pretty well.

Kathryn Sullivan
Four of my classmates were on it.

David Rubenstein
Did that make you think maybe you shouldn't go back a second time?

Kathryn Sullivan
Actually, it gave me greater resolve that we should go back. Before I ever joined the program, I had thought deeply about why hu-

If the goal was bold and included humans, it would push more science and technological advances across a wider front than any other kind of goal you could set. And the cascade of benefits that would flow from that over time into all walks of life would be extremely rich, comparable to what followed Apollo.

mankind does this, why the country does this, why I want to do this. In my judgment, there is worth in this pursuit of the frontier – both direct human exploration and robotic exploration. If one tragic accident had led my country to say, "Eh, never mind," I would have felt betrayed.

David Rubenstein
Surely your parents called you up after *Challenger* and asked, "Are you sure you want to do this again?"

Kathryn Sullivan
I am sure my parents had that conversation between themselves, but one of the things they were really generous about was never making their fears my problem.

David Rubenstein
Your second mission was on *Discovery*. And that time you were preparing the Hubble Telescope.

Kathryn Sullivan
Right. We took the Hubble Telescope up and put it into orbit.

David Rubenstein
How do you actually put it in orbit? Do you just open the shuttle bay and put it out there?

Kathryn Sullivan
You actually could do that.

David Rubenstein
How big is the Hubble Telescope?

Kathryn Sullivan
The Hubble is about the size of a school bus, about 54 feet long and just inches shy of 15 feet.

David Rubenstein
And it fit in the shuttle?

Kathryn Sullivan
It is set lying down in the shuttle and then bolted in on the sides.

David Rubenstein
So, how do you get it ready? Do you just open the doors?

Kathryn Sullivan
First we take the manipulator arm, the crane on the space shuttle, and use it to grab a special fixture on the telescope. Then, we undo all the clamps that hold it down. Next we pull the power cord out and lift it up above the orbiter and hold it there for a fair period of time while folks on the ground run through commands for the antennas and solar arrays to unfold, get it all ready to be on its own in orbit, and make sure everything is working well. If something wasn't working well, we could button it back up and bring it home and fix it.

Once the basic checkout is squared away, we open the clamp on the arm and pull the arm a little bit away. Now the telescope and the orbiter are just a little bit apart, both doing 17,500 miles per hour. So we back the space shuttle away from the telescope and leave it there on its own.

David Rubenstein
Explain what went wrong with the Hubble Telescope. Was the problem with how it was put together?

Kathryn Sullivan
The telescope has an eight-foot-diameter mirror that needs a precise mathematical shape so all the rays of light can be brought to a focus. The Hubble mirror was made too flat at the margins by about one-fifth of a human hair, which sounds super tiny but the shape needed to be exact. Basically, they made a mistake. They had two ways of measuring to check that the shape was correct: an old-fashioned way and a newfangled way using a laser altimeter. The old-fashioned way said, "No, no, you are wrong. It is not shaped correctly," but the newfangled method said, "No, it is okay."

The team was behind schedule. They were being pressured to stay on budget. And instead of stepping back and re-measuring with fresh teams on each side, they convinced themselves that the new tool was correct and the mirror was shaped correctly. But the new tool had been assembled incorrectly, and a shim that should have been in one place was in another, and the error correlates precisely to the dimension of that shim.

The bad news is that they made a mistake. The good news is that the mistake was very precise, which means, like an optician, we can calculate a very precise correction and restore sight.

David Rubenstein
When it became apparent that the Hubble wasn't working the way it was supposed to, did the Hubble scientists say, "Well, it was the astronauts who didn't do it right?"

Kathryn Sullivan
When we uncradled the telescope, we were doing something we had practiced in computer-driven simulations over and over again, but now we were doing it in the real world. And the real mechanical arm had some lag in it and some hysteresis to it, and the motors were driving just a little differently than what the computer modeling showed.

Steve Hawley was the person running the arm. He started slowly lifting the telescope up, this billion-dollar-plus, very fragile thing with only so much clearance to get it out. It started wobbling and moving in ways we had never seen in the simulator. So, we went very slowly, got it out, and then went home. And unfortunately then the problem showed up.

Charlie Bolden and Steve Hawley, in particular, spent a couple of weeks really worried that maybe they had bumped the telescope and not realized that as they were inching it out. But none of the repercussions came at the Astronaut Corps, because it was clear the fault was in the shape of the mirror, and that had been set years before any astronauts had been involved.

David Rubenstein
Ultimately, it was repaired, and the Hubble Telescope today is three times as powerful as when you put it up there. How did that happen?

Kathryn Sullivan
Hubble was designed to be maintainable in orbit, and one of the tasks we had as the deployment crew was to make sure it had all the tools and all the procedures it needed, and we checked them on the telescope. We had to guarantee they worked.

Since then, five repair crews have visited the telescope. The first one restored the sight, put the corrective lenses in, changed solar arrays, and did a number of other things. In terms of the sophistication of the repairs and our confidence in what we were doing, over time we have gone from what you might classify as doing auto mechanics at 17,500 miles per hour to performing microsurgery in space.

When we put Hubble in orbit in 1990, it had really 1970s technology, and it was expected to have a fifteen-year lifespan. Every instrument has been upgraded with 1990s and early-twenty-first-century detector technology, so it is now three times more sensitive. It has vastly higher data rates, much faster data rates with the ground, and much higher onboard storage capacity. Other than the mirror and basic skeleton that holds the mirror, Hubble is in every respect an altogether new telescope. Come 2020 it will mark its thirtieth anniversary.

Mankind's ability to live and operate and observe our planet from orbit has made it possible, for the first time in human history, to take a snapshot of conditions across the entire globe at once.

David Rubenstein
The Hubble telescope today is in many ways better than any telescope on Earth. Why is that?

Kathryn Sullivan
It still has an edge on optical telescopes. Hubble sees, basically, in the visible wavelengths plus or minus tiny bits – just as our eyes do. Hubble's advantage is being above the clouds and out of all the turbulence and scattering that the atmosphere imposes when you are looking at visible light.

Ground-based telescopic technology has narrowed the gap with Hubble over the years, though, by using thinner mirrors or mirrors made out of an assemblage of smaller mirrors, with mechanical systems on the back that can warp and push them. To deal with the turbulence of the atmosphere, you fire a laser toward the target you want to look at. You then measure the scattering the laser beam experiences along that path and calculate how that waveform was affected by the atmosphere. Then you can command the actuators on the mirrors to compensate for that "atmospheric seeing" and thus take out a lot of the disturbance.

David Rubenstein
When you came back from your second mission, did you want to go for a third? How do you get permission to go for a third time?

Kathryn Sullivan
How crews are assigned and who gets picked and why is one of the great black-box secrets of the Astronaut Corps. You clearly have to show your stuff and be seen as competent and deliver on assignments, but beyond that it is anybody's crystal ball.

We had a very mysterious, Machiavellian senior leader running things when I was there, not an astronaut but a senior administrator. One school of thought was that you needed to be one of George's kids and hang out at the bar with George, and since George liked softball, you should go play softball.

A cohort of people turned their life around to be George's kids, but then you could look at the flight pattern and say, "I don't know that any of those guys really got anything from being George's kids." I think the criteria for getting flight assignments – other than performing well – were always mysterious by design.

David Rubenstein
At this point several hundred Americans have been in space. Looking back dispassionately, is there any reason we had to send humans into space? Could we not have accomplished everything just by sending machines into space?

Kathryn Sullivan
If all you want is data, machines can gather data – assuming you know with certainty what it is you want and what qualities the data must have. If that is uncertain, if you are trying to figure something out for the first time, then having broader human faculties present on the scene still has, in my opinion, tremendous value.

Secondly, there has never been a ticker tape parade for a robot. There is something about the human experience. Being in your own wedding is different than looking at someone else's wedding pictures. Being at the rim of the Grand Canyon is different than getting a postcard from someone or seeing someone's picture. Your sense of understanding of what that place is, your sense of connection to what it means or what it inspires in humankind, happens by the direct human experience and by the direct person-to-person sharing of that experience, not by ones and zeroes.

David Rubenstein
Would you be in favor of our space program going back to the moon?

Kathryn Sullivan
If I ruled the universe, I would go Kennedyesque again. I would set a bold goal that sparked imagination, that was deliberately chosen to be beyond current technical and risk-management capabilities. The trick then is, "Don't blink." Just go for it.

The array of sciences, technologies, and capabilities that such a goal would advance, the hurdles and unknowns we would be compelled to push beyond, would be numerous and varied. If the goal was bold and included humans, it would push more science and technological advances across a wider front than any other kind of goal you could set. And the cascade of benefits that would flow from that over time into all walks of life would be extremely rich, comparable to what followed Apollo.

We are only on this planet temporarily. I have great respect for cultures that have an ethos of thinking of the seventh generation and counting it as genuinely being on their watch to take account of that seventh generation.

David Rubenstein
Apparently, several thousand people have said they would be willing to go to Mars and not return. If there was a mission to Mars, would you be willing to go on it?

Kathryn Sullivan
Part of me instantly says, "Yes!" Part of me thinks about the people who set off for the colonies hundreds of years ago or embarked down the Oregon Trail. They didn't know they were going to get there, but they were going to give it a go, hoping that something better was on the other side.

For me personally, a lot would depend on who was asking and what was the stated purpose. If Elon Musk is selling tickets and it is some sort of "golly gee whiz" commercial venture, I don't know that I would risk that. It would be risking my life for somebody I am not sure I trust on the risk factor.

If it was a national commitment for stated purposes along the lines of what we aimed for as a country in Kennedy's era, something worth committing your life to with a risk but also a purpose, that kind of equation could make some sense to me. And then it would be who are the people doing it. I think about the team of people that made up NASA and my flight crews, and none of us were perfect. We knew we were going to make mistakes and that no one can guarantee that everything is going to go right. But if I am confident that everyone's commitment to the purpose, to the mission, to its success, and to our collective safety is as strong as mine, I'll take that risk with those kinds of people.

David Rubenstein
As an astronaut and somebody who cares about the space program, is it embarrassing that we cannot launch humans into space anymore and have to depend on the Russians to do that?

Kathryn Sullivan
To be honest, I was disappointed when we discontinued our missions. It was purely a financial decision of the Bush presidency. If you have a new idea for a spacecraft, you are going to get to the point in which you have to bend metal and do more expensive things than drawings and analyses. You have to cut something out so that your budget stays flat. I would have preferred for our national sovereignty and national strength that we had retained launch capability while we built a new spacecraft instead of just seeing how long it might take for the private sector to step into the breach.

David Rubenstein
When you are on a shuttle mission, if you have an appendicitis attack, a kidney stone attack, or a heart attack, what do you do?

Kathryn Sullivan
We always had two folks on each crew who had mini-EMT training. Contaminants in your eyes are a common issue because things are floating in the air that would normally end up on the floor. We had a very good medical kit and we had a consultation line open with a flight surgeon on the ground if we needed it. We could stabilize urgent things, even do a tracheotomy.

Then, depending on the urgency, you could deorbit and be back on the earth in under an hour for something extreme. But if you needed to choose the landing site and make sure you had the necessary emergency support on the ground, you might have to delay for a few hours.

David Rubenstein
The *Apollo 8* mission was the first time humans came around the backside of the moon, saw the dark side of the moon, and then saw the earth rising. Some people say that led to the beginning of the environmental movement, because in the images the astronauts took you saw this blue speck. Can you talk about how it inspired you to think about the importance of the oceans and the importance of the earth as a place where you want to preserve the environment?

Kathryn Sullivan
Earth and geography, using the broadest sense of the word, have fascinated me from a very young age: people, cultures, landscapes. At the time of the *Apollo 8* mission, I was intending to pursue a language and linguistics career and figuring out how to parlay that knowledge into exploring the world. But like every other person, I was mesmerized and just stunned by that first view and then the eloquence of the Christmas Eve broadcast.

If I ruled the universe, I would go Kennedyesque again. I would set a bold goal that sparked imagination, that was deliberately chosen to be beyond current technical and risk-management capabilities.

They read from the beginning of Genesis. Even now, I feel a little chill down my spine and can almost see the picture again in my mind's eye. At that moment it did not fire a passion that I must save the earth, but I think it did play a strong role in awakening an environmental consciousness. All the icons of literature and art across our society and around the world were drawn to that picture.

David Rubenstein
When you were at NOAA, you sparred with members of Congress over climate change.

Kathryn Sullivan
A little bit.

David Rubenstein
Is there a credible scientific argument that the earth's climate is not changing?

Kathryn Sullivan
There is none. We know that weather is the variations of temperature and precipitation through a 24-hour cycle. The dynamics of the atmosphere and the ocean system at timescales longer than two weeks is what we call climate. And, of course, it changes. There is very strong evidence in the geologic and plant record of massive changes over time. The earth has tremendous natural variability.

The earth is also a greenhouse planet. None of us would live here if it was not a greenhouse planet. The predominant greenhouse gas in our atmosphere is water vapor. That is why we are all here.

There are several drivers of the natural variability, but we have a very good handle on what magnitude each of those other drivers can produce. Changes in the sunspot cycle, variations in the inclination, variations in the aerosol content: they happen. They have an influence, but they are very small in scale compared to the change since the Industrial Age in the concentration of CO_2.

There are people who have argued with me that going from 300 parts per million to 400 parts per million on an atmosphere our size seems trivial. But we are talking about an exquisitely balanced system, and we know that some of the active gases – CO_2, methane, bromine – while they have a similar effect to water vapor, have higher amplitude effects.

Think of the 250-pound man who has a bite of shellfish or eats a peanut and in moments is in anaphylactic shock. Or the tiny bee that stings a 300-pound person, who in short order is in potentially fatal shock. Precise, finely balanced systems often have fine sensitivities that defy our intuition, and key radiative gases like methane, bromine, and CO_2 have that kind of amplifying effect in our atmosphere.

David Rubenstein
As a scientist, therefore, you think there is no doubt that there is climate change. But the people you dealt with in Congress or elsewhere who say there is no climate change, what is their best argument?

Kathryn Sullivan

I recall a particular sparring match I had with one member of the House of Representatives, Lamar Smith, who accused career NOAA scientists of manipulating temperature records under coercion to fit the Obama administration's climate action plan and desires leading up to the Paris conference in 2015.

There was zero truth to the claim: for example, the fact that the data were taken over X number of years, that the NOAA scientists didn't collect the data, that it was independent data, that we were accused of being secretive about methods despite the fact that the entire methodology and all the data had been published in the open literature before the spat ever began.

The other arguments they make vary. People will throw out the sunspots or other natural factors. My sense is that at root this battle is really about not wanting to acknowledge that a collective issue of human activity on the planet affects us all, because something that affects all of us tends to require some collective response. It asks me to give up autonomy. It asks me to give up sovereignty. It asks me to change my lifestyle or put at jeopardy a business plan that is currently working for me.

Their best pushback is to say, "You don't have certain enough evidence yet." But that is like telling your medical provider, "You just told me you want me to give up smoking and donuts. I don't think I am that unhealthy yet. I don't think the high blood sugar is that much of a problem yet. I don't think it is quite that dire yet. That is a big change to make, and I don't want to accept that I need to make that change."

David Rubenstein

Today, when you deal with people who think there is no climate change problem or that it is not caused by humans, do you try to convince them otherwise, or do you just say, "I am going to deal with other issues?"

My sense is that at root this battle about climate change is really about not wanting to acknowledge that a collective issue of human activity on the planet affects us all, because something that affects all of us tends to require some collective response.

Kathryn Sullivan

I will engage in the debate. I think it is a debate we need to be willing to have with each other. I am glad the debate has opened a second front, which took about a decade or so to do, because whatever your views may be of causality, the patterns we have been accustomed to for decades and centuries are changing. The data and the patterns are shifting. The statistics are not stationary anymore.

The average temperature in April at a certain place is no longer the same as it always was. Your gardening magazine will show you that. The plant hardiness zones have been marching northward. Fish will show you that. They are leaving to follow the isotherms. Farmers will tell you that. Ranchers, some of the most politically conservative members of the agriculture sector, will tell you that this isn't working the way it always used to work.

So that opens a front where people are looking for actionable data. They are looking to better understand their risks. They are looking to try to understand how to adapt or prepare for changes that are already happening and changes that are coming. I think that opens up a potentially productive front on deciding how we act and live together.

The causal issue is a real one. At some point, it has to be dealt with. John Holdren would say, "Manage the avoidable and avoid the unmanageable." But how do you work on both of those fronts when it is still so politically toxic to talk about avoiding the unmanageable through some action to mitigate or control carbon?

NOAA played a key role in the scrubbing and removal of sulfur and nitrogen oxides from our atmosphere back in the 1990s, when the problem was acid rain. Market mechanisms played a tremendous role in making that happen. Emissions of those species today are in the 2–5 percent range of what they were in the early 1990s, and the reductions had an actual, substantive economic upside. Why we can't see around that corner when the chemistry involved is CO_2 still baffles me.

David Rubenstein

How do you respond to somebody who says, "Yes, I think there is climate change, and I even think humans cause it. But nothing I can do as a human is going to change the amount of carbon in the atmosphere in my lifetime or in my children's lifetimes, so why should I do anything that is going to affect people a century from now if I am not going to see the benefit of it?"

Kathryn Sullivan

Well that is the classic human trap. "It doesn't affect me now, and my linear thinking can't begin to contemplate that it could affect me in my lifetime, so I don't care." There is a moral dimension here. We are

People are looking for actionable data. They are looking to better understand their risks. They are looking to try to understand how to adapt or prepare for changes that are already happening and changes that are coming. I think that opens up a potentially productive front on deciding how we act and live together.

stewards of this planet. We are only on this planet temporarily. I have great respect for cultures that have an ethos of thinking of the seventh generation and counting it as genuinely being on their watch to take account of that seventh generation.

David Rubenstein
There are roughly 10 million species on the face of the earth now. Ninety-nine percent of all the species are extinct, and now we have 10 million left. An average species lasts about 500,000 years. A mammal lasts about a million years. We are between 200,000 and 300,000 years old. Do you think we will make it to a million years at the rate we are going?

Kathryn Sullivan
The planet will be fine a million years from now, but what the species mix will be is an open question.

David Rubenstein
If humans disappeared, who would rule the earth?

Kathryn Sullivan
Microbes.

David Rubenstein
Oh, really? It wouldn't be the cockroaches?

Kathryn Sullivan
Well, the insects might give them a go.

David Rubenstein
Today, as you look back on your career – which encompasses going into space, running NOAA, being an educator, talking eloquently about these challenges – what are you most proud of?

Kathryn Sullivan
I have been blessed to have been able to touch or inspire or give a boost of confidence to people at a point that mattered to them, people who have then done me the grand favor of circling back around and reflecting on where that let them get to and what that meant to them. I don't have any kids of my own, but I have fingerprints on a number of young and not-so-young folks.

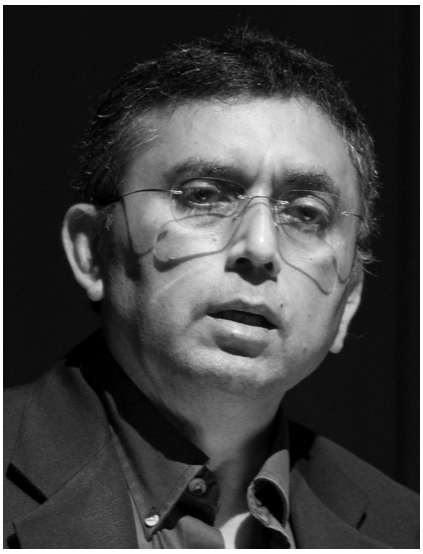
The greatest gift you can give or receive is to have the opportunity to make a meaningful contribution that is sincerely received in another person's life. So, I feel tremendously fortunate to have been able to do that, and I am proud of several of the people who have come back and shown me all the great things they have done. ■

To view or listen to the presentations, visit https://www.amacad.org/induction2017.

Morton L. Mandel Public Lecture

How Are Humans Different from Other Great Apes?

On October 23, 2017, at the Sanford Consortium for Regenerative Medicine in San Diego, California, the Academy, in collaboration with the Center for Academic Research and Training in Anthropogeny (CARTA), hosted the Morton L. Mandel Public Lecture on "How Are Humans Different from Other Great Apes?" The program, which served as the 2060th Stated Meeting of the Academy, included a welcome from **Gordon N. Gill** (University of California, San Diego School of Medicine; Chair of the Academy's San Diego Program Committee) and featured remarks from **Pascal Gagneux** (University of California, San Diego; CARTA) on Genomics, Life History and Reproduction; **Fred H. Gage** (The Salk Institute; CARTA) on Genetics and Brain Development; **Margaret J. Schoeninger** (University of California, San Diego; CARTA) on Anatomy and Behavior; and **Ajit Varki** (University of California, San Diego; CARTA) on Common Disease Profiles. The following is an edited transcript of some of the presentations.



Ajit Varki

Ajit Varki is Distinguished Professor of Medicine and Cellular & Molecular Medicine and Co-Director of the Glycobiology Research and Training Center at the University of California, San Diego; Executive Co-Director of UCSD/Salk Center for Academic Research and Training in Anthropogeny; and Adjunct Professor at the Salk Institute. He was elected a Fellow of the American Academy in 2005.

Introduction

It is a privilege and honor for an organization that is less than ten years old (namely, CARTA) to partner with one that originated before the U.S. Constitution was written (the American Academy of Arts and Sciences). A common theme supported by both organizations is the discovery and dissemination of factual knowledge. Time does not allow me to provide a description of the origins and goals of CARTA, so I will simply read our mission statement:

"*To use all rational and ethical approaches to seek all verifiable facts from all relevant disciplines to explore and explain the origins of the human phenomenon, while minimizing complex organizational structures and hierarchies, and avoiding unnecessary procedural complexities. In the process, train a new generation of scholars in anthropogeny [understanding the origin of humans], and also raise awareness and understanding of the study of human origins within the academic community and the public at large.*"

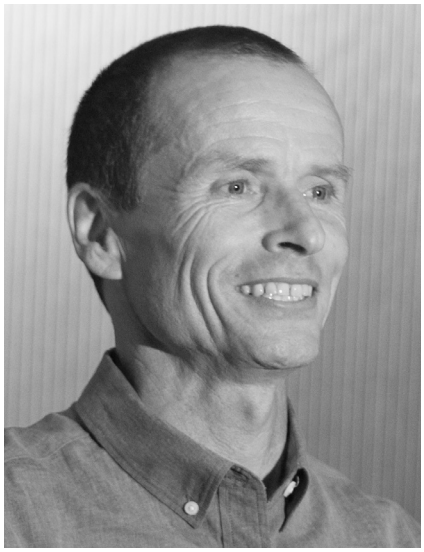
The overall question at hand today is: How Are Humans Different from Other Great Apes? At first glance, the last three words – "Other Great Apes" – may appear a bit strange. Let me explain. Humans are, of course, primates, who shared a common ancestor with Old World monkeys, then with Gibbons and other lesser apes, then with orangutans, followed by the gorilla and eventually with the common ancestor of the chimpanzee and bonobo, the so-called pygmy chimpanzee. Based on anatomical, physical, and behavioral features, we humans classified our closest evolutionary relatives as "the Great Apes." In reality we are more similar at the genomic level to chimpanzees and bonobos than these two species are to gorillas. Moreover, at the genomic level, we are more similar to chimpanzees than mice and rats are to each other.

Thus, from a genomic perspective, humans are nothing more than one kind of "Great Ape"; the correct term encompassing all these groups is "Hominid." Asking how we are different from the other Hominids is one way to understand our own evolutionary origins, an approach that we call "Comparative Anthropogeny."

Carrying out this comparison requires attention to a very large body of knowledge. One of the currently incomplete efforts of CARTA is to try to collate this knowledge on our website under the rubric of The Matrix of Comparative Anthropogeny (MOCA),

which is a collection of comparative information regarding humans and our closest evolutionary cousins, with an emphasis on uniquely human features.

MOCA is still very incomplete, but it is organized by Domains (each with defined Topics) arranged by areas of interest and scientific discipline. Some examples of MOCA Domains are: Anatomy and Biomechanics, Behavior, Cell Biology and Biochemistry, Cognition, Communication, Culture, Dental Biology and Disease, Development, and Ecology. In the time available today, we cannot possibly cover even a small portion of these Domains of knowledge. Instead, our panelists will explore some specific examples of distinctly human features, ranging from genetic to cognitive to anatomical to behavioral to biomedical, while also considering implications for explaining human origins.



Pascal Gagneux

Pascal Gagneux is Associate Professor of Pathology and Anthropology at the University of California, San Diego, and Associate Director of UCSD/Salk Center for Academic Research and Training in Anthropogeny (CARTA).

On Genomics, Life History, and Reproduction

I would like to start with a little bit of geography. Humans are the only periplanetary ape. In contrast to us, our closest living relatives are restricted to the tropical forests of Africa and Asia. As Ajit has just mentioned, we are more closely related to two species of these Great Apes. Some people have started debating whether we should be in the genus *Pan* or whether the two species of *Pan* should be in the genus *Homo*.

Paradoxically, the living apes, even though their populations are under very intense threat from deforestation and direct hunting, still contain more genetic variability than all seven billion humans on the planet today. The other striking contrast you might notice is that all the other apes, except us, exist in at least two different species, but there is only a single species of humans today that has colonized the entire planet.

One of the striking differences between humans and their closest living relatives is the schedule of life. In several aspects, humans have slowed down.

Each of us, as long as we live, is a unique mosaic of a genome that consists of 46 pieces of chromatin, reshuffled from our parents. Each of your haploid genomes is about a meter long. So you have about two meters of DNA in each one of your cells. That sounds mighty short, but each meter contains three billion base pairs, and therefore we have two times three billion base pairs.

One of the ongoing research projects in many labs around the world is to identify differences in the genomes of hundreds of different apes and thousands of different humans, which are now available for study because the entire genome, each of the three billion base pairs, has been sequenced.

The results are showing some very surprising findings. There are huge differences in copies. For example, there are copies of segments that can range from a couple of base pairs to millions of base pairs that have expanded in only one species of ape, or in chimpanzees and gorillas, but not in humans. In the reverse, we have copies of chunks of DNA that have only expanded in humans but not in the other apes.

And there are completely novel genes that pop up in different species. There are pseudogenes that are still recognizable based on their DNA sequence, but have

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stopped encoding proteins. You can mine the genomic data to find evidence for recent positive selection, in which natural selection has forced more changes to the protein-coding DNA than you would expect.

Humans are made of trillions of cells, and different cell types play a different subroutine off the mostly clonal genome that is in all your cells. So by tweaking where you express which combinations of genes, you can actually change how the organism looks.

I thought I would say a few things about the complex nature of the genomic landscape. In these three billion base pairs, we have about twenty thousand protein coding genes, which corresponds roughly to the number of undergraduate students at UCSD. There are hundreds of thousands of enhancers – chunks of DNA with a function, even though they never make proteins – that influence the activity of other genes. And many of these are transcribed. We don't know what that transcription really does. So, we have a vast genomic landscape, and we are only beginning to discover new functions for pieces of DNA that, until recently, were thought of as mere junk.

One of the striking differences between humans and their closest living relatives is the schedule of life. In several aspects, humans have slowed down. Our gestation time is only slightly longer than that of the chimpanzees, for example, but we have invented a couple of key things. Humans seem to have invented childhood, adolescence, certainly grandmotherhood, and sometimes grandparenthood for relatively long periods – up to 30 percent of the total lifespan is comprised of the post-reproductive survival phase.

Some have proposed that this might have been an adaptation to cultural opportunities, given the importance of cultural transfer in our species. Or perhaps it was due to nutritional opportunities, in which mothers with better access to high density-rich foods can actually do novel things in utero. It may also have been facilitated by stronger pair bonds between parents or by allomothering, which is when other individuals in the group help you take care of your kids.

Humans are made of trillions of cells, and different cell types play a different subroutine off the mostly clonal genome that is in all your cells. So by tweaking where you express which combinations of genes, you can actually change how the organism looks.

Now, what does this delay in growth allow? The delay allows increased transmission of behavior and concepts. Humans are eminent copiers. We hyper-imitate. In comparative studies of the transmission of tool use, chimpanzees are very good at imitating to achieve a goal. Humans, on the other hand, focus at least as much on how it is done and show normative tendencies.

Human minds are effective copying machines. Somebody comes up with a good idea, and then everybody in the group maintains that idea. We develop a ratcheting culture, in which we build upon each other's ideas.

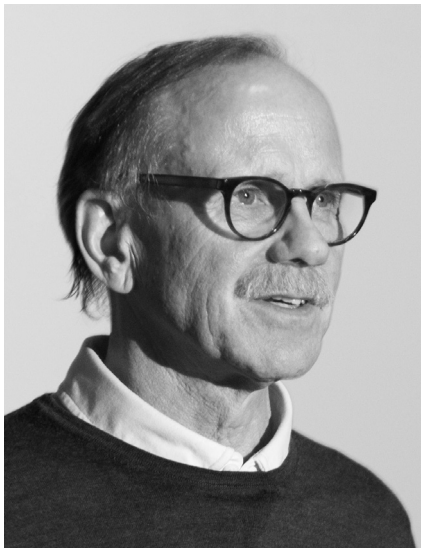
One very interesting idea is that this delayed development is actually a biological assimilation of the cultural input. Humans in hunter-gatherer societies have a shorter inter-birth interval than apes. Humans can give birth about every three years, chimpanzees only every five or more years. Even though our babies are costly, we can produce more of them than our living Great Ape relatives. And when humans are done making babies, they actually survive for a long time. Our societies, long before medicine, the Industrial Age, or the farming age, allowed for grandmothers and grandfathers.

Interestingly, in evolutionary biology it is pretty much accepted that toward the end of the reproductive period, there is a minimal force of selection. But if you allow for cultural transmission, post-reproductive individuals can actually facilitate the survival of related, younger individuals, which opens up later stages in life to the action of natural selection.

With regard to forming the next generation, what is striking is that to find strict monogamy in nonhuman primates, you need to look at the lesser apes, the Gibbons. They live only in the forests in Southeast Asia. The other Great Ape close relatives

have completely different mating systems: for example, the gorilla's harem-like societies, with the big Silverbacks that have exclusive access; the dispersed systems of the orangutans, with two types of males: the big males that are chosen by the females and the younger males that bypass female choice and force the females to mate with them; and chimpanzees and bonobos, with multimale/multi-female societies, in which each ovulating female will mate with every male in the group.

For humans, what is striking is that even though humans live in groups, pair bonding is a major phenomenon. This allows humans to participate in reciprocal exogamy, which essentially means exchanging mates across social groups. It allows for linking multiple kin lineages. Now, if you combine the cognitive capacity of our slowly maturing children, the allomothering, and the input of the group into each child, a striking array of things becomes possible. It essentially allows for our social-cultural niche. We share symbols. We have personal names. We have kinship terms, which allows for the formation of tribes. We have shared rituals, dance and music, sacred spaces, and group identity markers, and we can increase the capacity to cooperate with and compete against other groups.



Fred H. Gage

Fred H. Gage is Professor in the Laboratory of Genetics and the Vi and John Adler Chair for Research on Age-Related Neurodegenerative Disease at the Salk Institute, and Co-Director of UCSD/Salk Center for Academic Research and Training in Anthropogeny (CARTA). He was elected a Fellow of the American Academy in 2005.

On Genetics and Brain Development

I would like to provide you with an example or two of how a process may have led to the differentiation of humans from our closest relatives, and then talk about a cellular system that allows us to look at potential molecular and cellular differences that might have led to dissimilarities in who we are.

What we know is that the brain has increased in size across species during evolution along the branch that leads to humans. And we have come to the hypothesis that the growth of the brain is causally linked to what it is to be human. The correlation is placed there because as the brain became larger, we acquired features that seemed more unique to the complexity in behavior that humans can exhibit. For example, when we think about what are the measures that allow us to examine how we may have evolved, we can use genetic information. Svante Pääbo has been able to extract DNA from ancient bones and make a hypothesis about how that DNA may differ through evolution, particularly from our closest ancestral relatives.

We have established a bank of cellular tissues from many of our closest relatives that allows us to look at distinctions between ourselves and our closest relatives.

Sometimes we obtain postmortem brain tissue from our closest ancestral relatives. We can measure the magnitude of gyrations in the cortex and explore specific ideas or hypotheses about how they may be important. In addition, we have fossil crania to study and, from those skulls, we can build casts or make CT scans to get an idea of how the brain size was changing, again building our theories based on these measurements and the correlations that exist.

Furthermore, we have cultural icons as well that give us an idea of how far a species had emerged, given its ability to build, plan, and generate art.

In each case, we have material that we can work with: genetic material, tissues, organs, and cultural artifacts. What has been missing, however, is living tissue from some of our lost ancestors and from our closest relatives, like chimps and bonobos.

So the "missing link" is the ability to interrogate the activity and function of live

Chimpanzees and bonobos are our closest relatives, with 95 percent of our genomes being similar; yet, there are vast differences in phenotype. How can we begin to understand the cellular and molecular mechanisms responsible for these differences?

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As Pascal mentioned, chimpanzees and bonobos are our closest relatives, with 95 percent of our genomes being similar; yet, there are vast differences in phenotype. How can we begin to understand the cellular and molecular mechanisms responsible for these differences?

One of the things we can do is take somatic cells, such as blood cells or skin cells, from all of our closest relatives. Through a process called reprogramming – by overexpression of certain genes in these cells – we can turn the skin or somatic cell into a primitive cell, called an induced pluripotent stem (iPS) cell. These primitive cells are in a proliferating, living state that can be differentiated to form, in a dish, any cell of the body, allowing us, for the first time, to form living neurons or living heart cells from all of our closest relatives and then compare them across species.

These iPS cells represent a primitive state of development prior to the germ cell. So any change detected in these iPS cells will be passed along to their progeny through the germ cell and into their living progeny.

Now a little bit of a disclaimer for those of us who work in this field: these cells have limitations. They are cells in culture. We cannot really look at social experience, and their relevance to a living organism is oftentimes questionable.

But we can ask the question: are there differences that are detectable at a cellular and molecular level that help us understand the origin of humans? We have begun building a library with other collaborators around the world, and have reprogrammed somatic cells from many of these species into iPS cells. They retain common features of embryonic stem cells at the cellular level and they have the same genetic makeup as predicted based on the species.

In our first attempt to see if we could identify differences in these primitive cells, we did what is called a complete transcriptional (mRNA) analysis. If we compare the transcriptional genomes of chimpanzees and bonobos, there are very few differences. So we pooled all our animals together and compared that combined nonhuman primate group to the human group.

Are there differences that are detectable at a cellular and molecular level that help us understand the origin of humans?

In analyzing these genomes, we detected two very interesting genes. One is called PIWIL2 and the other is called APOBEC3B. Why are we interested in these two proteins? These two proteins are active suppressors of the activity of what we call mobile elements, which are genetic elements that exist in all of our genomes. In fact, 50 percent of the DNA in human genomes is made up of these mobile elements (molecular parasites of the genome). So what are mobile elements? They are elements that exist in specific locations in the genome and, through unique mechanisms, they can make copies of themselves and jump from one part of the genome to another. Barbara McClintock discovered these elements through her work on maize.

Some of us study a specific form of mobile elements called a LINE-1 retrotransposon. They exist in thousands of copies in the genome, as a DNA that makes a strand of RNA and then makes proteins that binds back onto the RNA, helping the element copy itself. This combination of mRNA and proteins then moves back into the nucleus where the DNA resides and pastes itself into the genome at a new location.

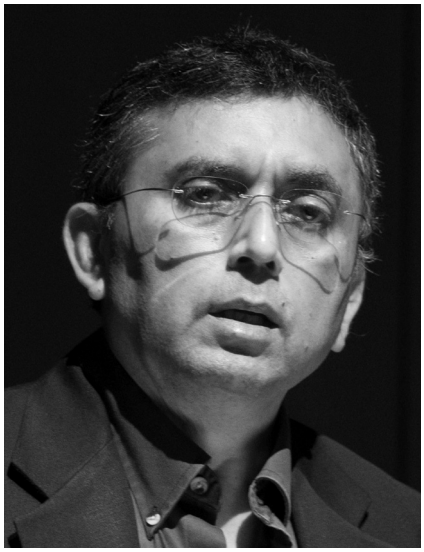
These LINE elements continue to be active in our genome, and they are particularly active in neural progenitor cells. Thus, the reason for our interest in PIWIL2 and APOBEC3B is because it has been demonstrated that both of these proteins can suppress the activity of LINE-1.

Not only do humans make more of these proteins, but as an apparent consequence, the lower levels of these L1 suppressors in chimpanzees and bonobos means the L1 elements are much more active in chimpanzees and bonobos than in humans.

When searching the DNA libraries (genomes) that have been sequenced for chimps, bonobos, and humans, there are many more L1 DNA elements in the genomes of chimps and bonobos relative to humans.

This greater number of L1 elements in non-human primate genomes leads to an increase in DNA diversity and, thus, in the

diversity of their offspring and potentially in their behavior. This led us to speculate that this decrease in genetic diversity that occurs in humans leads to a greater dependence on cultural adaptive changes to survive as a species rather than genetic adaptive changes. For example, if a virus were to infect a chimp or a bonobo population, in order for that species to survive it would require a member of the species with the genetic mutation that provided protection in some form from the virus. Humans do not wait for the mutation from a member of the species that would provide protection from the virus. We build hospitals, we design antibodies, we transmit our knowledge through cultural information (cultural evolution) rather than relying on genetics (genetic evolution) for the spread and the survival of the species.



Ajit Varki

Ajit Varki is Distinguished Professor of Medicine and Cellular & Molecular Medicine, Co-Director of the Glycobiology Research and Training Center, Executive Co-Director of UCSD/Salk Center for Academic Research and Training in Anthropogeny, and Adjunct Professor at the Salk Institute. He was elected a Fellow of the American Academy in 2005.

On Common Disease Profiles

In the 1990s, my research group happened to discover the first known genetic difference between humans and chimpanzees. Because I didn't know very much about our close evolutionary relatives, I took a sabbatical and went to the Yerkes National Primate Research Center to learn more about apes and chimpanzees. Given my medical background, I paid special attention to diseases, and I found that the Center was using Harrison's textbook of Internal Medicine, which is the same textbook I had used for humans. And so I thought, well, they must be just like us. And, indeed, when I first looked at the major causes of death in adult captive chimpanzees, the number one killer was heart disease, heart attacks, and heart failure. Again, I thought, well, they are just like humans. But then when I started going over the textbook with the veterinarian, I noticed that not all the diseases were the same.

Why do humans not often suffer from the fibrotic heart disease that is so common in our closest evolutionary cousins?

So the question arises: are there human-specific diseases? There are a few criteria for human-specific diseases: they are very common in humans but rarely reported in great apes, even in captivity; and they cannot be experimentally reproduced in apes (in the days when such studies were allowed). The caveat, of course, is that reliable information is limited to data on a few thousand Great Apes in captivity. But these apes were cared for in NIH-funded facilities with full veterinary care – probably better medical care than most Americans get – and there were thorough necropsies.

As it turned out, I was even wrong about heart disease. It was not until my spouse and collaborator Nissi Varki looked at the pathology that she realized that while heart disease is common in both humans and chimpanzees, it is caused by different pathological processes. While a human heart can show coronary blockage that reduces blood flow to the heart and results in myocardial infarction, heart attacks, and heart failure, chimpanzees that died of "heart attacks" and "heart failure" had a completely different pathology. They developed massive scar tissue replacing their heart muscle, which is called interstitial myocardial fibrosis.

It turned out that the veterinarians were well aware of this, but had not reported

We can draw several conclusions: The disease profiles of humans and chimpanzees are rather different. Chimpanzees are actually poor models of many human diseases. Humans are likely to be poor models of many chimpanzee diseases.

it because they thought it wouldn't be interesting because it was not like humans! There is now a special project called The Great Ape Heart Project, which is providing clinical, pathologic, and research strategies to aid in the understanding and treatment of cardiac disease in all of the ape species.

There are actually two mysteries to be solved: why do humans not often suffer from the fibrotic heart disease that is so common in our closest evolutionary cousins? They all can get it – the orangutans, gorillas, chimpanzees, bonobos – and we don't. Conversely, why do the Great Apes not often have the kind of heart disease that is common in humans?

Nissi and I then worked with Kurt Benirschke and with others and wrote an article on the "Biomedical Differences Between Humans and Nonhuman Hominids: Potential Role for Uniquely Human Aspects of Sialic Acid Biology," which focused somewhat on our own research on sialic acid biology.

We put together a list of candidates of human-specific diseases that meet the criteria I mentioned earlier, and myocardial infarction is number one. Malignant malaria is number two. In studies done from the 1920s to the 1940s, people actually did horrible two-way cross-transfusions between chimpanzees and humans infected or not infected with malaria, and there was no evidence of cross-infection. In fact, the parasites looked the same, but they were actually completely different.

More modern work done by Francisco Ayala and others showed that, in fact, *P. falciparum* arose from *P. reichenowi* by a single transfer from a Great Ape. Pascal Gagneux and I wrote an article that explains what might have happened. There are multiple forms of ape malaria that are mild throughout Africa. At some point, we escaped because of a change in the surface sialic acid molecule. One of them finally "figured out" how to bind to the sialic prominent in us, and that is now *P. falciparum* malaria.

Another candidate for human-specific diseases is typhoid fever. More horrible studies were done in the 1960s that showed that large doses of *Salmonella typhi* did not result in severe cases of typhoid fever in chimpanzees. Working with Jorge Galán and others we found that, in fact, what happened is that the typhoid toxin, which is the soluble molecule that really mediates the severe symptoms of typhoid fever, cannot bind to the chimpanzee cell surface. It can only bind to the human cell surface (again, because of the sialic acid difference between the species).

Why do the Great Apes not often have the kind of heart disease that is common in humans?

Another candidate is cholera, which is a major killer in humans. Robert Koch complained in 1884 that ". . . although these experiments were constantly repeated with material from fresh cholera cases, our mice remained healthy. We then made experiments on monkeys, cats, poultry, dogs and various other animals . . . but we were never able to arrive at anything in animals similar to the cholera process."

So, *Vibrio cholerae* does not induce diarrhea in adult animals other than in humans and many people are trying to figure out why.

There are many other candidates for human-specific diseases. There is another set of diseases in which various bacteria carry out molecular mimicry, in which bacterial capsular polysaccharides mimic common motifs on sialoglycans of mammalian cells – like a wolf in sheep's clothing.

Another difference is in carcinomas, cancers of epithelial origin. To date, no captive Great Apes have reported carcinomas of the esophagus, lung, stomach, pancreas, colon, uterus, ovary, or prostate. They do develop cancer in the hematopoietic system and elsewhere.

There are a few thousand Great Apes living in captivity, and living well into their fifties and sometimes into their sixties. So you would expect a few carcinomas based on the incidence in humans. Nissi and I wrote an article that reviewed the subject, and concluded that while relative carcinoma risk is a likely difference between humans and chimpanzees (and possibly other Great Apes), a more systematic survey of available data is required for validation of this claim.

Time does not permit me to talk about Alzheimer's Disease, HIV, hepatitis B complications, muscular dystrophy, preeclampsia, frequency of early fetal wastage, frequency of premature labor and birth, and frequency of chronic female iron deficiency. But bronchial asthma is interesting. Great Apes don't seem to get bronchial asthma,

an extremely common disease in all human populations. I found this claim a little hard to believe until I came across a paper entitled "Eosinophilic Airway Inflammation in a Monkey." The article concluded that the present case that was studied was "remarkable because there is a paucity of reports of naturally occurring allergic airway disorders in nonhuman primates."

So we can draw several conclusions: 1) The disease profiles of humans and chimpanzees are rather different. 2) Chimpanzees are actually poor models of many human diseases. We should pay more attention to that. 3) Humans are likely to be poor models of many chimpanzee diseases. The ethics of research on Great Apes has shifted and changed for good reasons. Pascal and I wrote an article with Jim Moore in 2005 that suggested we should conduct research on Great Apes that follows principles as similar as possible to those accepted for human research. We also suggested that researchers should volunteer to be subjects in the same experiments!

But like all things human, there are always two extremes and the people in the middle do not necessarily get a say. And so the question is whether the current ban on chimpanzee research will do more harm than good. I personally think it will do more harm because chimpanzees would also benefit from more ethical studies of their own diseases. But that is where we stand right now. ■

To view or listen to the presentations, visit https://www.amacad.org/great-apes.

Priorities for Progress: Advancing Higher Education in America

On October 26, 2017, the American Academy hosted a conversation at the University of California, Berkeley, on Priorities for Progress: Advancing Higher Education in America. The program, which served as the Academy's 2061st Stated Meeting, highlighted two Academy projects – The Lincoln Project: Excellence and Access in Public Higher Education and the Commission on the Future of Undergraduate Education. The following is an edited transcript of the presentations.

Monica Lozano

Monica Lozano is President and CEO of College Futures Foundation and a member of the University of California Board of Regents. She was elected a Fellow of the American Academy in 2016 and serves on the Academy's Commission on the Future of Undergraduate Education.

Among the many issues concerning student success that we identified, we found that for too many students there is sometimes no clear path to completion.

I was asked to provide a brief overview of the California public higher education landscape as it relates to college access and college success, thinking about it in the context of the work that we have done at the Academy for the Commission on the Future of Undergraduate Education. Among the many issues concerning student success that we identified, we found that for too many students there is sometimes no clear path to completion. There are the obvious interruptions and challenges any student may encounter along the way, but when they are compounded by academic preparation (the high school you went to), enrollment status (full or part time, working or not), demographic and socioeconomic status, race, gender, and ethnicity – all of these contribute to the uneven outcomes among students in terms of completion. In the Academy's forthcoming report on *The Future of Undergraduate Education, The Future of America*, we elevate promising practices, including one here at the California State University (CSU) and Long Beach Community College. But the overarching conclusion is that we need integrated strategies with a clear and transparent map to completion. Let me address this in the context of California.

Under the 1960 Master Plan, California organized its three-segment system of public higher education to fulfill the promise that *all* qualified students who wished to enroll would be provided with access to the state's public colleges and universities. To support access for students from all backgrounds, generous financial aid is available that covers the full cost of tuition at a UC school or at CSU for low-income students.

California's bachelor-degree-attainment rate is consistent with the national average (around 23 percent). California residents have consistently valued, been proud of, and (arguably) invested in public higher education. If we look closely at today's students and how the system works for them, however, a more nuanced story emerges – one that poses plenty of challenges.

Who are today's students? Low-income and first-generation college students – most of whom come from racial or ethnic groups that have historically been underrepresented in higher education – are the face of California's future. Today, almost two-thirds of California's public school students are from low-income families or underrepresented student groups, and they are the majority of California's high school graduates.

How is our system of higher education working for them? As you might imagine, outcomes differ dramatically based on race, ethnicity, and income. Although low-income and first-generation college students are the majority of our high school graduates, their bachelor's degree completion rates are only one-third of that of white and Asian students. Underrepresented students represent about one-half of high school graduates but only 28 percent of the total bachelor's degree graduates. Students from low-income families (in the bottom income

quartile) earn bachelor's degrees at about a quarter of the rate of those from high-income families (in the top quartile).[1] California has the dubious distinction of having the highest college completion gap between whites and Latinos, at 34 percent. In short, here in California chances of finishing a college degree are dramatically lower if you are born into a low-income family, if you are born African American or Latino, or if you grow up in a certain region of the state.

We all know that the benefits of a college education, and particularly of a four-year degree, are many. College completion contributes to the economic vitality of our communities, state, and nation by preparing an educated and skilled workforce for the knowledge economy of the twenty-first century. A college education provides social mobility and increased earning power for individuals and their families. And it contributes to a more robust democracy by equipping individuals with the skills not just to observe society but to participate in it.

College graduates are more likely to earn more, vote more, volunteer more, hold onto their jobs, be wealthier, and use public assistance less than people without a college degree. A four-year college might not be for everyone, and many Americans live meaningful lives without a college degree, but the reality is that a college degree offers greater freedom: freedom to choose a career and to choose one's path in life.

When fewer than half of students who begin college earn a two- or four-year degree within six years, a focus on access and enrollment is important but not enough.

Given the importance of degree completion, how does our higher education system provide opportunity for all students who would benefit from earning a degree? How well does the system function, with all segments working in tandem toward the shared goal of student success?

Unfortunately, each segment, from K-12 through higher education, has its own goals, its own incentives and disincentives, its own policies, its own funding streams, its own data, and its own governance. For students – particularly low-income and underrepresented students – completing a degree requires navigating a complicated and sometimes unwelcoming maze. What should be an open pipeline with strong joints is not always so, and the structural misalignment is where we see many of the most obvious gaps in college completion.

Of course, there are many other challenges, such as lack of readiness; limited access to resources, supports, and guidance; access to financial aid; clear guided pathways; impacted campuses; remediation; and time to degree, among others.

Low-income and first-generation college students – most of whom come from racial or ethnic groups that have historically been underrepresented in higher education – are the face of California's future.

Here in California, the entry point for low-income and underrepresented students is the California Community Colleges (CCC). Getting the transitions right and clearing the pathway to a degree is especially critical for these students. The California Community Colleges are the nation's largest higher education system. California's high school graduates are more likely to attend community colleges than high school graduates in other states. California ranks fifth nationwide in the share of recent high school graduates who enroll in community colleges compared to forty-seventh in the share who start at four-year schools. Of California students who enroll in a public higher education institution, nearly 70 percent enroll in a CCC.[2]

For its part, the CSU is the largest university system in the country and educates the most ethnically, economically, and academically diverse student body in the nation. The CSU six-year graduation rates of 57 percent, although steadily increasing, are not what they could or indeed need to be, and outcomes differ substantially depending on a student's race, gender, or campus location. For example, systemwide graduation rates are 64 percent for white students, 52 percent for Hispanic students, and 42 percent for Black students. Hispanic students graduate at rates 5 percentage points lower than the overall average and 12 percentage points lower than white students. Black students graduate at rates 15 percentage points lower than the overall average and a full 22 percentage points lower than white students.

Depending on the campus, the graduation rate changes drastically. The highest six-year graduation rate is 76 percent at CSU San Luis Obispo, while the lowest rate is 35 percent at CSU Dominguez Hills – more than 40 percentage points lower.

In 2016, CSU Chancellor Tim White announced Graduation Initiative 2025: an ambitious plan that aims to increase graduation rates for all CSU students while eliminating opportunity and achievement gaps for underserved students. The initiative focuses

1. *Helping Students Cross the Finish Line* (San Francisco, Calif.: College Futures Foundation, 2017) and underlying sources.

2. U.S. Department of Education and Public Policy Institute of California.

on encouraging innovation, removing barriers that impede student success, and being more strategic in how they serve students.

The UC schools educate hundreds of thousands of students, provide a significant impact on the state economy, have a laudable overall six-year graduation rate of 84 percent, and graduate low-income and transfer students at rates comparable to their peers. By comparison, the systemwide Pell-eligible student graduation rate is 83 percent.

Freshman graduation rates have increased for all racial and ethnic groups, although graduation gaps remain between underrepresented student groups (African American, American Indian, and Hispanic/Latino) and white and Asian undergraduates. Six-year graduation rates are 74 percent for African American students, 78 percent for Latino students, and 86 percent for white students. Depending on the makeup of the student body and the academic and support conditions available to students, there are vast differences in college completion.

The data that I have shared are just a snapshot of where we are as a state, but there is a bigger context for all of this and a set of challenges that require visionary and pragmatic leadership.

Some may refer to this as Tidal Wave III. Our cohort of prospective students is the most racially and ethnically diverse ever. The K-12 system is making progress in terms of the academic preparation of our children so that more students are graduating from high school having met the requirements to go into two-year or four-year colleges. But we are not prepared on the higher education side to provide room and opportunities for these students, although we as a state have essentially promised them that opportunity.

Meanwhile, California faces a shortfall of over one million baccalaureate degrees by 2025 because of changes in the economy and the retirement of baby boomers now in the workforce. And we have a system of financing our public universities – how we plan and pay for student access and success at the CSU and UC schools – that is not functional, and not serving students, the institutions, or the state well.

When fewer than half of students who begin college earn a two- or four-year degree within six years, a focus on access and enrollment is important but not enough.

The Master Plan has been the touchstone for higher education policy in California for more than half a century. The promise of the Master Plan is at risk, however, as opportunities for access and degree completion are eroding in the face of continued fiscal crises, resulting in rising prices and fewer opportunities for California's resident students. The public university systems that worked so well for previous generations of Californians need a fiscal re-boot to meet the needs of current and future generations.

So what will we do to ensure opportunity, close the gaps, and plan for our state's future? We must meet the growing demand for college: California students are now better prepared for college. However, there is no room for them. Thanks to the administration's successful policies and increases in funding for the K-12 system, the state's high school graduation rates have been steadily increasing over the past eight years. The proportion of high school graduates meeting A-G requirements grew from 34 percent in 2003–2004 to 45 percent in 2015–2016. However, these successes in the K-12 system have created a capacity problem, such that qualified California students are being turned away from the state's public four-year colleges: Between 2005 and 2015, nearly one million California residents who applied for freshman or transfer admission to the California State University or to the University of California were turned away.

In the CSU system, seventeen of the twenty-three campuses are unable to enroll all qualified applicants in the majors to which they apply because of capacity limitations.

In the 2015–2016 academic year, CSU campuses rejected more than seventeen thousand qualified freshman applicants. Between fall 2010 and fall 2014, more than fifty-one thousand qualified freshman UC applicants were redirected from their preferred campuses to UC Merced (fewer than a thousand of those students enrolled).

Additionally, as this administration's reforms take hold in the California Community Colleges system, leaders expect as much as a 35 percent increase in students seeking transfer to a four-year school.[3]

Education is a public good. Our colleges and universities are incredible assets; so too are our young people. Higher education should continue to be the pathway to opportunity and a stronger, healthier, inclusive, and functional society – not the driver of inequity. The key to increasing degree attainment among Californians will lie in educational practices that reduce and ultimately eliminate racial and ethnic gaps in degree attainment. If California policy-makers and higher education leaders are not able to increase access and degree attainment among

3. *Securing the Public Trust* (San Francisco, Calif.: College Futures Foundation, 2017), Public Policy Institute of California, and underlying sources.

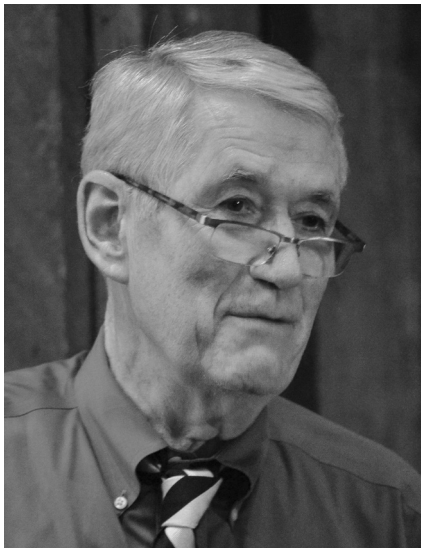
low-income and first-generation groups, the state will face a future of growing economic stratification and inequality, with the dividing line between the haves and the have-nots increasingly dictated by educational achievement.

Let me end with a closing note to our audience and my fellow panelists. California has often led the nation when it comes to important issues of the day. Just consider where we are today in terms of climate change and emissions standards. This is a time for us to articulate a Bold Goal for California College Success.

For California to be *the* global leader in providing not just broad but equitable access to quality public higher education, we must recommit and reinvest in a system that expands access, ensures a sustainable financial model that is also affordable for families, and, most importantly, ensures student success to and throughout college.

Can we challenge ourselves and others to take a systems-wide approach to thinking about this as a pre-through-16 continuum with shared responsibility for student success among all educational institutions?

It is time for us to set overarching, long-term goals for our education ecosystem, working together with the state's K-12 system, and paying special attention to transition points between high school and post-secondary education, and between two-year and four-year institutions.



Robert J. Birgeneau

Robert J. Birgeneau is Chancellor Emeritus and the Arnold and Barbara Silverman Distinguished Professor of Physics, Materials Science and Engineering, and Public Policy at the University of California, Berkeley. He was elected a Fellow of the American Academy in 1987 and served as Cochair of the Academy's Lincoln Project: Excellence and Access in Public Higher Education.

An inevitable consequence of the fact that state funding of public higher education is not going to return to the halcyon days of yore is that our country must have a new compact to support public higher education.

I would like to review briefly some of the data that led up to the Academy's Lincoln Project and then focus on more recent data from a project led by Charlie Eaton and Henry Brady that is looking at the specific challenges of need-based financial aid at a national level.

So, just a little background about The Lincoln Project. In the early 1980s, the state of California provided the University of California with about 52 percent of its budget. In 2011, that number dropped to 10 percent.

When I was recruited to be the Chancellor of Berkeley, Bob Dynes, the President of the UC system at that time, had made a compact with Governor Schwarzenegger that funding from the state would increase at a rate of about 4.5 percent per year. I was told that there was every expectation that this would hold true. Fortunately, I was not that naïve. But even given my wariness, I could not have anticipated that state funding would fall so dramatically. At Berkeley, if the compact with Governor Schwarzenegger had held true, in 2008 we would have had $590 million in state funding. Instead, we received $240 million: we were short $350 million in our operating budget. Everybody in this audience knows the sorts of challenges that we faced in this time period as a result of this budget shortfall.

One of the most dramatic aspects of this massive state disinvestment was that we had a complete inversion in the sources of our funding. In 2003, the year before I came to Berkeley, student tuition was a relatively small part of our total budget while state support had by far the largest share. In 2003, Berkeley was truly a state-funded institution. However, as a result of the disinvestment by the state, our budget simply inverted itself so that we found ourselves in the situation in which state support now constituted only a minor share (10 percent) of our total budget. This meant that faculty and staff salaries were basically paid for by student tuition. We were no longer em-

We have a dire need for increased state-funded, need-based financial aid because that controls both graduation rates and student debt.

ployees of the state. In essence, we became employees of the students. Approximately two-thirds of faculty and administrative staff salaries are now paid by the students.

This situation, which turned out to be a national phenomenon, led to the establishment of the American Academy's Lincoln Project: Excellence and Access in Public Higher Education, which documented the role in American society of public research universities, analyzed economic trends affecting their operations, and recommended new strategies to sustain and strengthen these critical institutions. The project produced five publications, and in our fifth and final publication, we proposed various strategies for moving forward. These strategies implicitly assumed a different outcome in the November 2016 election, and so unfortunately our efforts to implement the recommendations of the Lincoln Project have been curtailed for now. However, I am an eternal optimist so I believe that we will be able to return to those strategies once we have leadership at the federal level that is more committed to higher education and a business community that understands fully the necessity of having a robust system of public higher education in the United States.

Our strategy called for "a new compact" for the support of public higher education. One of our conclusions, which I initially was very reluctant to accept, is that the state disinvestment in higher education is irreversible. This disinvestment did not just happen in California. It happened in Tennessee; it happened in Michigan; it happened in Virginia. It happened because the forces that operate on state governments from a variety of directions will not reverse themselves. This means that the challenges currently facing public higher education will not be reversed simply by having students protest at our state capitols or having the business community lobby state legislators on behalf of higher education.

So what are the major components of the discretionary part of state budgets? The largest amount is spent on K-12 education. Next, there is Medicaid, then higher education, and finally corrections. One of the most dramatic changes in state-government funding concerns corrections. Over the last three decades, funding for higher education with all the ups and downs has remained relatively constant (not including the recent draconian cuts), but spending on corrections has increased by 141 percent. In many states we spend more money on incarcerating people than we do on giving them a higher education and unfortunately this trend does not appear to be reversible. In California, over the last several years, the prison population has decreased by 30 percent, but the costs have barely moved. It turns out that the marginal costs are such that even decreasing significantly the prison population by letting people with low-level drug offenses out does not solve the problem.

Student debt is low, generally speaking, much lower than what you read in the newspapers.

An inevitable consequence of the fact that state funding of public higher education is not going to return to the halcyon days of yore is that our country must have a new compact to support public higher education. That compact must involve the federal government, state and local governments, the business community, foundations, philanthropists, the colleges and universities, students and their parents. There is no silver bullet. This is discussed in detail in the final publication of The Lincoln Project.

After completing The Lincoln Project, we realized that we needed more information on need-based financial aid at the national level. Such aid is critical to both accessibility and to college completion rates. Accordingly, Henry Brady, Mary Sue Coleman (who directed The Lincoln Project with me), Mike Hout, and I decided that we needed to initiate a project on need-based financial aid across all public universities – not just research universities, which is what The Lincoln Project focused on. We did not include community colleges that have their own unique challenges, and so the data that I will share with you include all four-year public institutions, but not community colleges.

Several people were involved in collecting and analyzing the data: Charlie Eaton, who is an assistant professor at UC Merced; Sheisha Kulkarni, a graduate student in economics at Berkeley; Henry Brady; John Stiles; Mike Hout; and myself. Our first report appeared on the website of the Center for Studies in Higher Education this past February.

It turns out that obtaining reliable and consistent data on low-income students and their financial support over all four-year public colleges and universities is extremely difficult. Every state has its own conventions for collecting and reporting the relevant data. Thus, comparing apples to apples is quite challenging. As a surrogate for the numbers of low-income students we use the number of federal Pell Grant recipients at an

institution. The first question that we asked is what colleges and universities do low-income students typically attend. The data show that they are mostly not at research intensive public universities. Across the country, approximately 20 percent of the students at high research universities are on federal Pell grants. This contrasts with universities that have little or no research or only a small amount, where typically 50 percent of their students come from low-income families. Thus, the reality is that low-income students state-by-state are underrepresented at the flagships and are much more likely to be attending four-year colleges that do not have Ph.D. graduate programs.

Low-income students are twice as likely to attend public universities that have little or no research.

What about need-based financial aid across the country? In my opinion, it is a national disgrace that the absolute majority of states have little or no need-based financial aid. This is the reason for the very low graduation rates and the high dropout of low-income students from universities in these states. By contrast, three states stand out – California, Wyoming, and New Jersey – in providing funding for low-income students that matches that from federal Pell grants.

What about student debt? We often hear numbers that have no basis in reality. If we look at only public research universities, only about half of the undergraduate students have debt when they graduate, and if they do, it is typically less than $30,000. For example, here at Berkeley, the average debt on graduation for the 50 percent of students who have debt is about $19,000. The apocryphal stories of countless students with debts of $100,000 to $200,000 are just not true. They may make good press, but they are gross misrepresentations.

If we ask how much debt do students have, we find out that the amount of debt varies inversely with how much financial aid they get. The more financial aid they get, the lower the debt at graduation. This is not surprising.

Now if we look at students defaulting on their student loans, at non-research universities we find that 35 percent of students default on their student loans. Many of these defaulters are students who failed to graduate so they do not benefit from the increased income that comes from graduation. At research universities like Berkeley with very high graduation rates and high incomes of its graduates, the default rate is 10 percent.

Thus, based on these data our conclusions are as follows: 1) We have a dire need for increased state-funded, need-based financial aid because that controls both graduation rates and student debt. 2) Student debt is, in fact, low, generally speaking – much lower than what you read in the newspapers. 3) Low-income students are twice as likely to attend public universities that have little or no research. 4) Loan default rates are 10 percent at top public research universities and 35 percent at non-research universities.

This is where we stand right now with this project on low-income students at public universities and need-based financial aid. We are currently refining these data to obtain as complete and reliable information as possible. We will not solve the problem of income inequality in the United States if we do not simultaneously reduce the education gap between the privileged and the underprivileged; need-based financial aid is a critical component of this reduction.

Bob Jacobsen

Bob Jacobsen is Dean of Undergraduate Studies in the College of Letters & Science and Professor of Physics at the University of California, Berkeley.

To continue to engage thousands of students, we have to figure out a way to actually resource that activity. We all know that the last ten years have been incredibly hard, but we have managed to succeed with a high-tuition, high-aid approach to what we do.

My role here is to comment as a practitioner and to give you an on-the-job view from Berkeley. Let me stress that these are my own thoughts, and I suspect the higher up you go in the hierarchy, the more the perspective might differ.

I think we all agree on the need for more support for public education and for our flagship institutions. I think we all agree on the mission to grow at each generation the leaders, achievers, and creators that society needs, and to provide access and opportunity across all of society. The points that were raised about how today's student population represents a wider range of students, and that over the last thirty years, Berkeley has come to embrace more first-generation students and more students from low-income families with low social capital are all very important because this is changing the experience of Berkeley from the 1960s.

To continue to engage those thousands of students, we have to figure out a way to actually resource that activity. We all know that the last ten years have been incredibly hard, but we have managed to succeed with a high-tuition, high-aid approach to what we do.

Now our tuition, at just over roughly $13,000 when you roll in some fees, is not high on the scale of Princeton or MIT. But it is high for a lot of the families that are sending their children to our schools. So although this model has succeeded in allowing us to bring in tens of thousands of students who have no financial resources at all and are able to study at a great place like Berkeley, this is not the time to be at all complacent about the model because it is already starting to show significant cracks. I believe it is time for us to find another approach because what we have is not going to work in another five or ten years.

Don't get me wrong; we will always provide financial aid to our students. Let me share a story to help you see why. Last weekend was Parents Weekend, which is an opportunity for alumni parents to come back to campus and complain about how the old days are gone. They have earned that right. I am perfectly okay with it because I have a strategy for dealing with it. When someone comes up to me and says, "I was in the class of 1975, and we only paid $240," I smile and reply, "Yes, that is true. But how did you pay for your rent?" You get into some very interesting conversations about this question. Five of the people who I had this conversation with last Saturday said, "I lived at home, or the money came from home, or Dad got me a job that paid lots of money and I didn't have to show up." Do you see a pattern here?

If you are a first-generation student from Compton, none of those options are available to you. We are trying to reach out to students who don't have dads that can get them you-don't-have-to-show-up jobs and who are unlikely to have parents who can send them money.

We have deliberately set out to do this. Financial aid will always be necessary to help those students who need assistance paying for their living expenses in a place like Berkeley, where you need $20,000 a year or more just to survive as a student.

Let me come back to this idea that money from home doesn't work anymore. You have to know a little bit about how the financial aid system works. And as an aside, actually understanding financial aid should be an academic discipline. It is that complicated. I have helped multiple foster children navigate the system. I have studied the system. I have worked in the system, and I still do not understand it well enough to help a student fill out the forms. Let me also mention that Professor Judith Scott-Clayton of Columbia University wrote an excellent paper for the Academy that provides a rough overview of financial aid in only 14 pages with 42 explanatory footnotes.

The basic calculation that you need to understand goes like this. A student starts by filling out a form called the FAFSA. Some of

the questions, such as their name, are relatively simple; others are very esoteric. There is literally a question that says, and I quote, "Be sure that the AGI calculation has included calculations of past insurance carryovers." I finally figured out what that means, but none of my foster children could understand it. There are also other forms that parents have to fill out, which can be difficult to do in complicated, modern families. Then there is a federal government calculation that determines the maximum that the family can be reasonably expected to contribute, which in most cases becomes what the family must contribute.

Each school determines how much students need to come up with on their own via work-study, or a summer job, or loans. At Berkeley, this amount has risen recently to almost $9,000. And realistically, if you take a few thousand dollars' worth of loans, you will have less than $30,000 in debt after four years. A summer job can help to generate a few thousand dollars so the system can work.

The difference is the need that is met by various kinds of financial aid. So, roughly speaking, if you add on living expenses to $13,000 worth of tuition, you have to figure out where to get that $35,000 or $36,000. For low-income students that source will be Pell Grants and state grants, and it works. For middle-income students, it is also something like that. But now we begin to see why the money-from-home option doesn't work for middle-class families. We have already assessed everything that these families can give and we have taken it from them. The federal government's calculation is not in the slightest bit generous, and it extracts quite a bit. A family earning less than $230,000 is expected to pay for everything that they can for the student. And it is only when you reach the income that gives you something left over after this calculation that you could possibly send money to the student. Another way to say it is that without state support, we have to extract every dollar we can from middle-class parents.

Financial aid will always be necessary to help those students who need assistance.

Each school determines how much students need to come up with on their own via work-study, or a summer job, or loans. . . . The difference is the need that is met by various kinds of financial aid.

Since the campus needs to raise more funds, the stress gets more intense. We end up with our students feeling like they are living on a knife edge, which is very far from the 1970s experience of show up, learn something cool, maybe get a job, ask Mom and Dad for enough money to pay for the rent, and it is going to be okay. The knife-edge example is used a lot by our students because – although they wouldn't say it this way – they feel that they can fall off, get cut, and be hurt because they are balancing this very large bill and this very large financial aid in ways that they don't fully understand.

Yesterday, I spent some time with a student who has not received her financial aid check for this semester because she was selected for an audit by the IRS two years ago. The paperwork got lost somewhere, and that has now delayed her financial aid for this semester. We will fix this problem, but it is an extremely stressful thing to get her temporary money to tide her over.

Thousands of our students are having this problem on any given day. Out of the 18,000 students that I am responsible for, somewhere between 1,000 and 2,000 are having a problem with their financial aid.

This is not a criticism of our financial aid office. They are skilled people who work extremely hard. They are very committed to making this work, but they have to administer an extraordinary number of different forms of aid and scholarship. They are trying to get every dollar in the students' hands and they succeed, but that operation alone costs millions of dollars. And if we continue to move in a direction of more and more funky scholarships, more and more little programs that do this and the other, we have a scaling issue that we just don't know how to deal with.

I absolutely agree with the number that 80 percent of our students do quite well with respect to loans. It is actually a little bit better than that at Berkeley. But 4 percent of our students graduate with over $50,000 worth of loans. Now, no system can work perfectly and I understand that, but that 4 percent represents quite a few people. And they tend to come from places that fall through the cracks in the system. An acrimonious divorce, for example, can lead to paperwork not being submitted for financial aid. It happens a lot.

Legal troubles are another issue. We have a student who received an award for being the best student in her department and she had to drop out for a semester because she had used all of her financial aid to pay the legal fees to keep herself from being deported. And now she is in trouble because those legal fees were not part of her bud-

get. It is a very hard thing to think about how Berkeley works as a social agency to deal with the problems of its students. We have to think about that and consider how far our commitment goes. This particular student went on to excel in her studies, and we are going to be very proud of her at some point. We just have to figure out how to make this work.

Less visible in the numbers is student workload, and I don't mean from your classes. I mean from commitments outside of your classes. Thirteen percent of our students filed paperwork to say that they were working more than 15 hours a week last semester. I would rather have them working in your labs, working with you in your offices, working in your libraries.

Nevertheless, we are succeeding in some ways, and so the question is what is the new model going to be? We cannot keep going this way. My bottom line is that Berkeley will never have $35,000-a-year tuition and $35,000 worth of financial aid because we cannot make that system work. We will not be able to serve all of these people who come from the various parts of our community. But somehow we have to find a way to make this work, and I am actually pretty optimistic that there is such a way to do it.

Michael S. McPherson

Michael S. McPherson is President Emeritus of the Spencer Foundation. He was elected a Fellow of the American Academy in 2014 and serves as Cochair of the Academy's Commission on the Future of Undergraduate Education.

I would like to make a few broad points that emerged from the deliberations of our Commission on the Future of Undergraduate Education. We are building on success in this country when we think about the future of higher education. It is easy to worry and there are plenty of reasons to worry, but we are at a place that very few countries have ever reached. The fraction of our overall population that has a college degree is, I believe, the highest in the world. Ninety percent of our high school graduates have some experience of college before they are thirty years old. That number is impressive.

We are trying to do something we have never done, which is to give everybody a shot at a higher education, and we should be proud of that. We need to recognize how vital this is to our country's future.

One of the things our Commission considered was four scenarios of possible alternative futures.What if our future leans toward greater social division? What if employment changes radically and we move to a "gig economy" in which people are hired on a task-by-task basis and work on-demand instead of as full-time employees? What if the technologies that deliver higher education change dramatically? What if environmental disasters or other natural or human-made disasters impinge on us?

We need really good higher education that helps people to think better, to solve problems, to communicate across difference, and to be flexible in dealing with a changing world.

One thing that all those scenarios have in common is that in every case we need really good higher education that helps people to think better, to solve problems, to communicate across difference, and to be flexible in dealing with a changing world. Those are the things that higher education can provide.

We have huge problems. We have to get the money to where it will do the most good. Bob Birgeneau, Bob Jacobsen, and Monica Lozano have made this point very clear. But it is not an easy thing to do. It means recognizing that some priorities are higher than others, but in every state and in every college, we think putting the focus on the best use of those resources makes sense.

We have a long way to go. We think our Commission has some useful ideas as well as some important challenges and criticisms for people to consider. But I don't want us ever to lose sight of the fact that we are build-

ing on success, and that the work we need to do is urgent for the future of this country.

Discussion

Audience Question

The problem is overwhelming, and we all understand and accept that. But what I have not heard addressed this evening, but which I know you are all aware of and concerned about, is the role of philanthropy. What are the problems when philanthropic donations do not cover the most vulnerable students and families?

Robert Birgeneau

Philanthropy certainly plays an important role at the Berkeleys of this country. What the data that have emerged from the work Henry Brady and the rest of us have revealed is that the major challenges are not at the public flagship research universities, but at the non-research universities, in which philanthropy does not represent a realistic solution for them. They have very little philanthropic support and this is unlikely to change in the near-future.

Monica Lozano

Given my role as a member of the University of California Board of Regents, and recognizing this funding transformation that occurred in which we went from being heavily supported by the state to relying on tuition, we know that we cannot sustain this for much longer. The Regents are working with the chancellors across the system, and we are very focused on how to bring new philanthropic dollars into the UCs as a way of minimizing the impact on students. We need a financial model whereby the state invests appropriately in higher education, establish a tuition policy that is predictable, moderate, and by which families can plan, and then fill the gap with private dollars, primarily through philanthropy.

Michael McPherson

I agree with everything that was said about philanthropy, but I think another important dimension here is the need for better advising and guidance for students, which can, on the one hand, help people to get into places that will really work for them, and, on the other hand, can help people make financial choices that don't get them into a deep hole. Nationally, it is really clear that those who default on their student loans are the people who didn't finish, and they didn't finish in many cases because they made a poor choice about where to start. If you are a first-generation family, you cannot rely on the networks that many of us have. So spending money to get solid advice can actually be money well spent.

We need a financial model whereby the state invests appropriately in higher education, establish a tuition policy that is predictable, moderate, and by which families can plan, and then fill the gap with private dollars, primarily through philanthropy.

Monica Lozano

This question of navigating the maze is so important. When you come from a background that isn't familiar with the process, there are dollars available that go unused. There are resources for many hundreds of thousands of eligible families but because of the complexity of the system, they don't apply for this aid. So how do you remove the complexity? How do you make it something in which you need to opt out, instead of opt in? How do you use technology to provide the kinds of data gathering that will automatically populate the fields? We need to move in this direction and use new tools so families can take advantage of the financial resources that are available.

Bob Jacobsen

As a practicing advisor, let me say that the best way you can help navigate the system is to stop having systems. Every time we fix a problem by adding a new scholarship for left-handed people from odd-numbered zip codes, we make things harder and harder for the students we are actually trying to help. And that is one of the reasons why there is financial aid for low-income students.

Audience Question

I have no doubt that the California legislature values our diversity efforts and would like us to be even more diverse. But how do we convince the legislature that diversity is not a question of pure admission. It is a question of support: financial aid, academic support, and so on?

Monica Lozano

We know that it is not just about having access. Completing college is absolutely critical, and I think the legislature is starting to recognize this. And it is not about offering more dollars, but spending those dollars wisely. There is clearly a focus on the best use of resources. So how do we convince the state legislature that, in fact, we are doing everything we can to provide the resources where they can have the greatest impact. There was a bill that was passed last year that now very specifically provides for more

Our Commission certainly believes that if we acknowledge that what matters is not simply getting people in the door but having them succeed, then investing money in more success actually pays off.

support services at UC. It identifies students by socioeconomic and racial data, and allows us to determine the interventions that they will need along the way to be successful. These predictive analytics are allowing us to identify those students that need support to get through.

Michael McPherson

Our Commission certainly believes that if we acknowledge that what matters is not simply getting people in the door but having them succeed, then investing money in more success actually pays off. Fewer people would be wasting time and their own resources in something that they are not going to complete successfully. This does not mean that we don't want those people to try. We are willing to take risks, but we should have them try and then support their efforts to succeed.

Audience Question

One of the things that you have all demonstrated today is that the past is not our future, and that the future holds the need for new revenue sources. So, what are these new revenue sources? Continuing education, concurrent enrollment, more summer programs? At Berkeley my sense is that we may have the capacity and elasticity in our faculty to offer these programs with the resources that are available, but other universities may not.

Robert Birgeneau

Two of the non-participants in the support of the educational operations of public higher education in this country are the federal government and the business sector. We are the only country, of the countries that we compete with economically, in which the federal government does not support the operations of its great public research universities. One way or another, the federal government – in partnership with the states, philanthropists, and private enterprise – has to participate. In addition, it is my view that Corporate America is not paying its fair share of the costs of public higher education. I have had many conversations with the leaders of Silicon Valley firms who were complaining that we were not producing enough chemical engineers, enough electrical engineers, and other skilled researchers. My response was, "Well, you know, you can help solve that problem by providing direct support." I proposed a straightforward model in which every time a Silicon Valley company hires one of our graduates, they give a scholarship to support the next student coming along. Individual corporate leaders would say that this sounds like a very promising idea but they also said that in the end they were unlikely to fund a student who could well end up working for one of their competitors. However, one way or another, major corporations need to contribute directly to the cost of the education of the students that they are hiring. This is not specific to public universities. It applies to the privates just as well.

Audience Question

I would like to return to the issue of the pipeline. One of the panelists said that California is turning away lots of qualified students, and I would put the word *qualified* in quotes. In addition to financial need and providing guidance and advice to our students, they have to be prepared when they enter higher education. So I am wondering how much pressure can come from the Regents or other institutions of higher education to ensure that the students in the pipeline are, in fact, prepared to come here. And I am thinking especially of the students from economically disadvantaged backgrounds in which education has not been a high priority. How we can support the improvement in their preparation?

Bob Jacobsen

Let me offer a Berkeley specific example and then make a larger comment about this. For a long time, the UCs were not part of the ecology of developing teachers in California. Then roughly a dozen years ago, a governor's initiative broke that block. We have a program at Berkeley called CalTeach and its explicit goal as stated in its tagline is "a thousand grads for a million minds." Think about the student-to-faculty ratio implicit in that statement. But the UCs are really a drop in the bucket, unless we decide to get serious about producing the next generation of teachers. Unfortunately, this is a very hard thing to take on in a resource-constrained environment. And so my larger issue about the social impact of our programs depends on being able to create and nurture new programs. ■

Redistricting and Representation

On November 8, 2017, in collaboration with the Roy and Lila Ash Center for Democratic Governance and Innovation at the Harvard Kennedy School, the Academy hosted a meeting on "Redistricting and Representation." The program, which served as the Academy's 2062nd Stated Meeting, included presentations by **Gary King** (Harvard University), **Jamal Greene** (Columbia Law School), and **Moon Duchin** (Tufts University). **Chief Judge Patti Saris** (U.S. District Court, District of Massachusetts) moderated the program, which included introductory remarks from **Jonathan Fanton** (American Academy of Arts and Sciences). The speakers' remarks appear below.

Patti B. Saris

Patti B. Saris is Chief Judge of the U.S. District Court for the District of Massachusetts. She was elected a Fellow of the American Academy in 2014.

The Constitution requires that states must make a good faith effort to achieve precise mathematical population equality in Congressional districting, and the Equal Protection Clause of the Fourteenth Amendment requires the same in drawing lines for seats in the state legislature.

I want to welcome you all to this fascinating symposium hosted by the American Academy of Arts and Sciences on the topic of Redistricting and Representation. Let me begin by thanking the Academy for sponsoring so many different programs ranging from philosophy to science to law to nuclear war to education. Name a cutting-edge topic and the Academy is addressing it.

Today's topic on partisan gerrymandering spans issues of law, mathematics, and policy. The term "gerrymander" was coined after our own Elbridge Gerry, Governor of Massachusetts, who signed an 1812 law that included a voting district shaped like a salamander to help his party. Tonight's program is not about an esoteric topic, but one that is on the front burner of the Supreme Court in the landmark case of *Gill v. Whitford*, which was just argued before the Court on October 3, 2017. A split three-judge federal court in Wisconsin had invalidated a redistricting act passed by the Wisconsin legislature on the grounds that partisan gerrymandering violated the Equal Protection Clause. The Court found that the act was intended to burden the representative rights of Democrats by impeding their ability to translate their votes into seats, that it had its intended effect, and that the plan was not explained by the political geography of Wisconsin and was not justified by a legitimate state interest. There was a four-day trial with eight witnesses. This was the first decision in decades to reject a voting map as an unconstitutional partisan gerrymander.

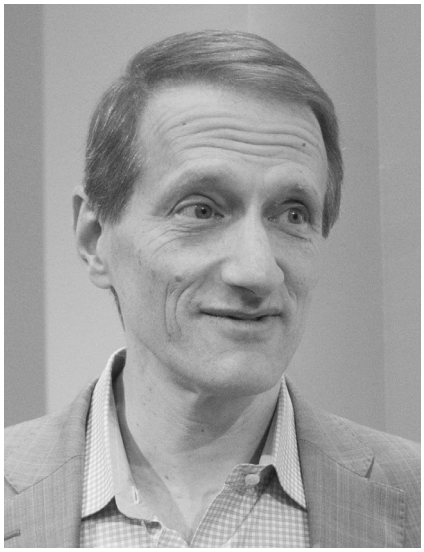
As background, the Constitution requires that states must make a good faith effort to achieve precise mathematical population equality in Congressional districting, and the Equal Protection Clause of the Fourteenth Amendment requires the same in drawing lines for seats in the state legislature. Most of you know that legal principle as one person, one vote. In addition, both the Constitution and the Voting Rights Act prohibit racial gerrymandering. What makes the *Gill v. Whitford* case so unusual is that it involves partisan gerrymandering, which means – loosely speaking – the common practice of the party in power to choose the redistricting plan that gives it an advantage in the polls.[1] The Supreme Court has tackled this issue before in fractured decisions and rejected the challenges, but some justices left open the possibility that such challenges were justiciable and manageable.

The debate before the Supreme Court was robust. Was this an equal protection problem? Was it a First Amendment question involving freedom of speech and association? Are there metrics like the so-called

1. *Davis v. Bandemer*, 478 U.S. 109, 164 (1986).

efficiency gap that make it feasible for federal courts to decide? At the oral argument, Chief Justice Roberts worried that the Supreme Court would have to decide in every case whether the Democrats or the Republicans would win, and "that is going to cause very serious harm to the status and integrity of the decisions of this Court in the eyes of the country."

I do not have answers to these three questions but hopefully our wonderful panelists will address the issues.



Gary King

Gary King is Director of the Institute for Quantitative Social Science and the Albert J. Weatherhead III University Professor at Harvard University. He was elected a Fellow of the American Academy in 1998.

In 1986, the U.S. Supreme Court declared political gerrymandering *justiciable*, which means that a plaintiff can ask the courts to throw out a legislative redistricting plan if the plan treats one of the parties unfairly. Since then, however, political gerrymandering has never been *justished* (OK, that's my word!), meaning that no plan has ever in fact been thrown out, nor has the Court established the standard that redistricting plans must meet.

So that was 1986. What was happening in 1987? Well, the most important thing going on then, from my point of view, was that I really wanted a job. The university down the road gave me an interview and the chance to give a job talk.[1] I discussed an article that was to be published that year in the *American Political Science Review* with my graduate school buddy Robert Browning.[2] In that article, we proposed a mathematical standard for partisan fairness and a statistical method to determine whether a redistricting plan meets that standard. We called the standard *partisan symmetry*.

As it has turned out, I am proud to say that since our article and my job talk, virtually all academics writing about the subject have adopted partisan symmetry as the right standard for partisan fairness in legislative redistricting.

Then, a little more than a decade ago, the Supreme Court actually said in an opinion (roughly!), hey you academics out there, if there were some standard that you all agreed on, we would love to hear about it. This led me to think, job talk time again!

So in the next redistricting case that reached the Court, my friend Bernie Grofman and I, along with a few others, filed an amicus brief telling the Court all about partisan symmetry.[3] By that time, partisan symmetry was not merely the near universally agreed upon standard among academics; it had also become the standard used by most expert witnesses in litigation about partisan gerrymandering. In fact, in many cases, including the one for which we filed the brief with the Supreme Court, experts on *both* sides of the same cases appealed to partisan symmetry.

The Supreme Court explicitly discussed our brief in three of its opinions, including the plurality opinion. All of the justices' discussions in their opinions of our brief, and the parti-

1. Thanks to the members of the search committee: Jim Alt, Mo Fiorina, and Bob Putnam!

2. Gary King and Robert X. Browning, "Democratic Representation and Partisan Bias in Congressional Elections," *American Political Science Review* 81 (1987): 1252–1273, copy at http://j.mp/2n5Y11v.

3. Gary King, Bernard Grofman, Andrew Gelman, and Jonathan Katz, "Brief of *Amici Curiae* Professors Gary King, Bernard Grofman, Andrew Gelman, and Jonathan Katz in Support of Neither Party," U.S. Supreme Court in *Jackson v. Perry*, 2005, copy at http://j.mp/2gw1W1R.

san symmetry standard, were positive. It appeared that, if a redistricting plan were ever overturned, the standard adopted by the Court would have to involve partisan symmetry. But the justices in that case did not go so far as to overturn the redistricting plan before it, or to explicitly adopt a standard for future cases.[4]

Since 1987, data on voters have gotten better. The science has advanced. Statistical methods used to determine whether a plan meets the standard have improved. With high accuracy, we can now determine whether an electoral system meets the partisan symmetry standard after a set of elections, after just one election, or, without much loss of accuracy, before any elections have been held at all. These methods have been rigorously tested in thousands of elections all over the world. The standards are clear and the empirical methods are ready.[5]

Now along comes a new Supreme Court case, *Gill v. Whitford*. With a few colleagues, I filed a new brief in that case, reminding the justices about partisan symmetry and clarifying some other issues.[6] The case has not yet been decided, but judging from the oral arguments last month, partisan symmetry is again a central focus. By the way, I highly recommend listening to the oral arguments; they were remarkably sophisticated and intense, quite like a high-level seminar at a leading university. (Although beware, and much to my chagrin, all references to "Professor King's brief" in the oral arguments were to the brief I filed a decade ago, with no mention of the one I filed in this case!)

In 1986, the U.S. Supreme Court declared political gerrymandering *justiciable* – which means that a plaintiff can ask the courts to throw out a legislative redistricting plan if the plan treats one of the parties unfairly.

But let me say something about partisan symmetry: how it is really simple, and why you should support it too. A good example comes from the case presently before the Court. At issue is a redistricting plan passed by the state of Wisconsin in 2011.

In the 2012 election, Republicans received 48 percent of the votes statewide and, because of the way in which the districts were drawn, more than 60 percent of the seats in the state assembly. It may seem strange that the Republicans received a minority of the votes and a majority of the seats, but strange does not make it unfair. What makes it vividly unfair is the next election in Wisconsin: In 2014, the Democrats happened to have a turn at receiving about 48 percent of the votes. Yet, in that perfectly symmetric voting situation, the Democrats only received 36 percent of the seats. Moreover, we know from considerable scholarship in political science that this is not going to change. In all likelihood, no matter how many elections are held in which the Democrats happen to receive about 48 percent of the votes, they are not going to come close to having 60 percent of the seats – for as long as the districts remain the same. That's unfair. And the reason it is unfair is because it is asymmetric.

This is a dramatic Republican gerrymander. But remember we have analyzed thousands of elections and know that the Democrats have done just as much damage when they are able to control the redistricting process.

To be clear, any translation of votes to seats is fair – as long as it is symmetric. For example, some states require redistricters to draw plans that make competitive elections likely – so 52 percent of the votes might produce 75 percent of the seats rather than say 55 percent, which is fair so long as the other party would also get 75 percent of the seats if they also got 52 percent of the votes.

Other states require redistricters to draw plans that favor incumbents, perhaps so that members of Congress from their state will have more seniority and thus influence,

4. Bernard Grofman and Gary King, "The Future of Partisan Symmetry as a Judicial Test for Partisan Gerrymandering after *LULAC v. Perry*," *Election Law Journal* 6 (1) (2008): 2–35, copy at http://j.mp/20w4pQ8.

5. Gary King, "Representation Through Legislative Redistricting: A Stochastic Model," *American Journal of Political Science* 33 (1989): 787–824, copy at http://j.mp/2046Gkk; Andrew Gelman and Gary King, "Estimating the Electoral Consequences of Legislative Redistricting," *Journal of the American Statistical Association* 85 (1990): 274–282, copy at http://j.mp/2nRBBOO; Andrew Gelman and Gary King, "A Unified Method of Evaluating Electoral Systems and Redistricting Plans," *American Journal of Political Science* 38 (1994): 514–554, copy at http://j.mp/20T1ZqA; Stephen Ansolabehere and Gary King, "Measuring the Consequences of Delegate Selection Rules in Presidential Nominations," *Journal of Politics* 52 (1990): 609–621; Gary King, "Electoral Responsiveness and Partisan Bias in Multiparty Democracies," *Legislative Studies Quarterly* XV (1990): 159–181, copy at http://j.mp/204k5Jc; Andrew Gelman, Jonathan Katz, and Gary King, "Empirically Evaluating the Electoral College," in *Rethinking the Vote: The Politics and Prospects of American Electoral Reform*, ed. Ann N. Crigler, Marion R. Just, and Edward J. McCaffery (New York: Oxford University Press, 2004), 75–88, copy at http://j.mp/20vY86M.

6. Heather K. Gerken, Jonathan N. Katz, Gary King, Larry J. Sabato, and Samuel S.-H. Wang, "Brief of Heather K. Gerken, Jonathan N. Katz, Gary King, Larry J. Sabato, and Samuel S.-H. Wang as *Amici Curiae* in Support of Appellees," Filed with the Supreme Court of the United States in *Beverly R. Gill et al. v. William Whitford et al.*, 2017, 16–1161, copy at http://j.mp/2iJAMZl.

which will yield a result closer to proportional representation, with seat proportions closer to vote proportions.

In fact, I think I can convince you that you have already invented a symmetric electoral system when you go out to dinner with a group and need to choose a restaurant. The decision rule most people choose is called the *Unit Veto* system whereby any one person can veto the outcome. This decision rule is fair because it is symmetric – it is not only Bob or Sally who can veto the choice; *any* member of the group can. This is an extreme system, one we probably would not choose for electing members of a legislature, but it is one of the numerous possible symmetric and thus fair electoral systems.

The point is not only that partisan symmetry is the obvious standard for a fair electoral system. It is also that, if the Court adopts partisan symmetry, it will still be leaving considerable discretion to the political branches in each state, something that the Court sees as essential.

Partisan symmetry leaves redistricters lots of other types of discretion in drawing districts as well. One is compactness, which many states and federal law require. The paper I wrote with my graduate students Aaron Kaufman and Mayya Komisarchik, and distributed at this event, provides a single measure of compactness that predicts with high accuracy the level of compactness any judge, justice, or legislator sees in any district.[7] There are also criteria based on maintaining local communities of interest, not splitting local political subdivisions, having equal population, not racially gerrymandering, and many others. Partisan symmetry may be related to some of these in some states but the standard does not absolutely constrain any one of these criteria.

In fact, a huge number of other factors are also chosen by redistricters, most of which no court, constitution, or legislature has ever tried to regulate, and few of which have even been written about. Moreover, these other factors could not be more important to those responsible for redistricting. None are constrained by partisan symmetry.

Partisan symmetry is a widely accepted mathematical standard for partisan fairness in legislative redistricting. Statistical methods have been invented to easily determine whether redistricting plans meet this standard.

Here is an example. To learn about redistricting and to obtain access to data, I occasionally sign on as a statistical consultant. I estimate the deviation from partisan symmetry for every proposed redistricting plan, determine the degree of racial bias, and compute compactness, among other things.

During this process, one of the legislators was raging mad about the proposed plan, just fuming. Well, one of the things I do whenever I am near partisans and have access to data is to compute the probability that they will win the next election. It turns out these predictions are straightforward and highly accurate. Knowing these predictions helps reveal the motives, interests, and desires of most everyone. (And don't judge: no matter how noble the goals of politicians, if they don't first attend to their own reelection, they won't be able to do anything else.)

So I looked up my forecasts for this apoplectic legislator and said, "what are you upset about? You are going to win this election with about 75 percent of the vote." At that point, he was pacing and insisting, "Look at the plan, look at my district!"

So I said, "Yes, but you are going to be reelected. What do you want, 85 percent of the vote? What is the big deal?" He then explained, "Look at this line," pointing to one of the boundaries of his district. "Do you see where it excludes this little area and then continues? That's my kids' school. And this? That's where my wife works. And this? That's my mom's house!" He then pointed to the map on the wall of the entire state and said, "Previously I had a nice compact district where I could drive to see any constituent. Now the district is splayed halfway across the state, and it will take me all day flying to get anywhere! They are just trying to annoy me. They are trying to get me to resign!"

And they were trying to get him to resign. So we looked into it – systematically, across many elections and many redistricting plans.[8] It turns out that, during redistricting, incumbents are much more likely to resign, and that causes the partisan division of seats in the legislature to be more responsive to changes in voter preferences, at least compared to no redistricting. Redistricting is a nasty process, probably the most conflictual form of regular politics this country ever sees, with a good number of fist fights, examples of hardball politics, and many really unhappy bedfellows. Imagine if some guy you

7. Aaron Kaufman, Gary King, and Mayya Komisarchik, "How to Measure Legislative District Compactness If You Only Know it When You See it," working paper, 2017, copy at http://j.mp/2u9OWrG.

8. Andrew Gelman and Gary King, "Enhancing Democracy Through Legislative Redistricting," *American Political Science Review* 88 (1994): 541–559, copy at http://j.mp/20w4XoP.

don't know in a basement playing with maps once a decade could get you fired! As a result, legislators often prefer to retire over the risk of getting drawn into a district with another incumbent, perhaps having to run against your friend, or ending a successful career being humiliated at the polls in a new district dominated by opposition party voters.

In fact, lack of redistricting does not mean no change. Voters move, die, come of age, immigrate, emigrate, and come to the polls in different numbers. Over time, without redistricting, nothing constrains the electoral system from moving far from partisan symmetry. Some states become horribly biased on their own, without moving district lines.

In contrast, if you control a state's redistricting, you are likely to restrain yourself to some degree. Why? Well, you can gerrymander in your favor, moving your state far from symmetry, but if you go too far and wake the sleeping judicial giant, you might have the entire process taken away from you. If that happens, you lose not only the opportunity to win a few more seats for your party, but also the opportunity to have completely free reign over everything that may otherwise make your life, and that of your party members, miserable.

So redistricting increases responsiveness and reduces partisan bias relative to no redistricting at all. In that sense, aspects of messy partisan redistricting battles can be good for democracy.

But it also means that the Supreme Court can play a fundamental role and reign in much of the excesses of gerrymandering without much trouble. All they need to do is to eliminate the worst cases by adopting the partisan symmetry standard, and to outlaw the worst excesses. If the Court takes this minimal action, redistricters – jealous of their prerogatives – will stay well away from the line. Any line, even one that is not bright white, will greatly increase the fairness of American democracy. The problem here is not some foreign power meddling in our election system; the problem is on us as Americans. And the institution in American politics to fix the problem is the Supreme Court; it is the only institution capable of fixing this problem. We certainly know from two hundred years of partisan redistricting battles that no legislature will save the day.

So as I wait with the rest of the country for this Court decision, I feel a little like I am in the same position I was thirty years ago – hoping someone will like my job talk.

Jamal Greene

Jamal Greene is Dwight Professor of Law at Columbia Law School.

I want to spend my time talking about partisan gerrymandering in legal rather than social scientific terms, and why it is such a vexing issue, more vexing than it might appear on its face. I will begin by offering some remarks on the case law of the Supreme Court before discussing some of the obstacles to clear thinking in the area of partisan gerrymandering.

The Supreme Court first addressed the constitutionality of partisan gerrymandering in a 1986 case called *Davis v. Bandemer*. That was a case involving redistricting of the state legislature in Indiana after the 1980 census. There, Justice White said that a party could prevail on the claim by showing "intentional discrimination against an identifiable political group" and "an actual effect on that group." *Effect* meant "evidence of continued frustration of the will of a majority of the voters or effective denial to a minority of voters of a fair chance to influence the political process." This standard was borrowed essentially from racial vote dilution cases. You could show that a minority group's right to vote was diluted if you could demonstrate intentional effort to do so and success at doing so.

In some sense, with partisan gerrymandering the intent prong is easier than with race, but the effect prong is vastly more difficult. A racial minority group is often numerically smaller than voters from one of the major political parties, and so it is easier to frustrate a racial minority group's ability to influence the political process in a sustained way. Maybe more importantly, whether someone is a racial minority is a fixed characteristic in a way that is not true of whether someone is a Democrat or a Republican. Whether Democrats or Republicans have been denied effective participation in the political process interacts in complex ways with the substantive issues they tend to support or not support.

The Supreme Court has never held that the *Davis v. Bandemer* standard was satisfied. Indeed, in a 2004 case involving Pennsylvania redistricting, *Vieth v. Jubelirer*, four members of the Court were willing to say there is no judicially manageable standard. Justice Kennedy in that case agreed that there was no clear standard for declaring a violation in Pennsylvania, but he refused to say a standard might not develop in the future. The Wisconsin case argued last month, *Gill v. Whitford*, is an effort to revisit this question. The three-judge district court held that Wisconsin Republicans had created an unconstitutional partisan gerrymander, relying in part on a measure of wasted votes called the efficiency gap that I expect others to get into more deeply.

Interestingly, it appeared that every member of the Court in *Vieth* conceded that partisan gerrymandering was inconsistent with democracy. So if there is so much agreement as to the undemocratic nature of partisan gerrymandering, why has the Court not played a meaningful role to date?

I am going to list six obstacles and discuss each very briefly. In sum, they are: (1) constitutional design; (2) one person, one vote; (3) race; (4) what I will call the baseline problem; (5) geography; and (6) remedial concerns.

First, on constitutional design, the Constitution does not specify any particular democratic arrangement, nor does it by its terms exclude political influence over the structure of the electoral process. The manner of conducting elections for Congress, for example, is granted to state legislatures, with no explicit constitutional guidance over how to do that. There are a great many choices that need to be made, including whether to have districts at all, whether to represent individuals or groups or interests, how to count votes and declare winners, whether to have secret ballots or voice voting, and whether and how to structure political primaries and ballot access. And this is left largely to statutory law structured for the benefit of particular political interests. The constitutional text does not get us far in this area.

If there is so much agreement as to the undemocratic nature of partisan gerrymandering, why has the Court not played a meaningful role to date?

Second, one person, one vote does not prevent gerrymandering and in many ways it facilitates it. Because of one person, one vote, state legislatures are required to redistrict every ten years, and modern technology enables partisan gerrymandering simply

The manner of conducting elections for Congress is granted to state legislatures, with no explicit constitutional guidance over how to do that. There are a great many choices that need to be made . . . and this is left largely to statutory law structured for the benefit of particular political interests.

to plug the equipopulation constraint into the algorithm.

Third, there is an interdependent relationship between race-based and partisan redistricting. Under the Voting Rights Act, states in certain circumstances are required to create majority-minority districts. Many minorities, especially African Americans, vote overwhelmingly in favor of one party. Stuffing all of the supporters of the minority party into a single district is an effective means of partisan gerrymandering. And so there is a degree to which the Voting Rights Act actually requires a partisan imbalanced map.

Fourth, there is what you might call a baseline problem. Should an ideal map be based on creating competitive districts? Should its overriding goal be to treat the parties the same? Should it be focused on creating a degree of political stability, which might be in tension with competition and with treating parties the same? Should it aim at proportional representation? Note that a perfectly competitive election would make proportional representation quite difficult, since a wave election would cause a small change in support to lead to a large change in the number of seats.

Fifth, voters are not distributed randomly across a polity. Democrats tend to cluster in cities. If you were to use "neutral criteria," such as maintaining county or other municipal boundaries, the natural tendency might be to pack Democrats and put them at a disadvantage on a statewide map. So you need to have a theory that tells you whether this result is acceptable or not.

Finally, the only way to remove politics from the process is to remove politicians from the process. And so the Court needs to tolerate a certain degree of political control unless it is prepared to say that, contrary to all of American history, independent redistricting is required. Once you say some political control is allowed, the nature of the problem becomes a difference of degree rather than a difference in kind. Courts get very nervous about weighing in on questions of degree.

In sum, policing partisan gerrymandering through the courts is going to be an uphill climb, regardless of what the Supreme Court says in *Gill v. Whitford*.

Moon Duchin

Moon Duchin is Associate Professor of Mathematics and Director of the Science, Technology and Society Program at Tufts University.

For the purposes of this brief discussion, I need to begin by specifying redistricting as a math problem in some way; that is, by formalizing a districting plan as an appropriate kind of mathematical object. I will propose a way to do this that is completely uncontroversial: start with the smallest units of population that are to be the building blocks of a plan – these might be units given by the Census, like blocks, block groups, or tracts, or they might be units given by the state, like precincts or wards.[1] We can represent those population units as nodes or vertices in a graph, and connect two of them if the units are geographically adjacent.

For instance, Figure 1 shows a map of Wisconsin, and with it I have drawn a graph of its 1,409 Census tracts. You certainly can't see all the ones in Milwaukee by looking at this picture because the graph is too dense there, which illustrates that plotting the graph in this way (with the vertices at the centers of the tracts) also shows you where the population is clustered.

Armed with this, we can say that a (contiguous) *districting plan* is a partition of the vertices in the graph of a state's population into some number of subsets called *districts*, such that each district induces a connected subgraph.[2] For instance, Wisconsin currently has eight congressional districts and ninety-nine state assembly districts, so if they were made from Census-tract units, then the former districts would have between one hundred and two hundred nodes each while the latter would have only ten to twenty nodes.[3]

Our goal when we redistrict is to find a partition that meets a list of criteria. Some of those are universal and apply to the whole country, like having nearly equal populations in the districts and complying with the federal Voting Rights Act, and some are specified by states, such as guidance about shapes of districts or about how much to allow the splitting of counties and cities. Part of what makes redistricting so hard is that many of these rules are vague, and they often represent conflicting priorities.

The rest of this note will be devoted to outlining three intellectually distinct but not mutually exclusive strategies for measuring partisan gerrymandering. The first two are *only* suited for partisan gerrymandering, but the third is more flexible and can be used for other kinds of measurements of a plan, like racial bias or competitiveness. For each approach, we should track the norm and the baseline: how does the metric correspond to a notion of fairness? What is the basis of comparison against which a plan is assessed?

Partisan symmetry is a principle for districting plans that has been articulated and championed by Gary King, Bernie Grofman, Andrew Gelman, and several other prominent scholars.[4] At its heart is a certain normative principle (or statement of how fair plans *should* behave): how one party performs with a certain vote share should be handled symmetrically if the other party re-

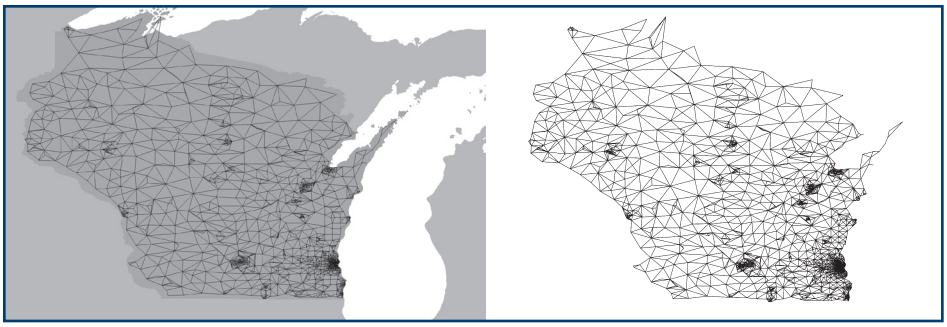


Figure 1. Wisconsin with the Census-tract graph overlaid, and with the graph shown separately.

1. A districting plan normally will not go below the Census block level, because then the population needs to be estimated. The units in which the election outcomes are recorded are called VTDs, or voting tabulation districts, which typically correspond to precincts or wards. These are natural units to build a plan from if you want to study its partisan properties.

2. It is generally reasonable also to require that no district is wholly surrounded by another district.

3. That is, if the districts were made out of whole tracts. In fact, typically they are made out of finer pieces, like precincts.

4. See Bernard Grofman and Gary King, "The Future of Partisan Symmetry as a Judicial Test for Partisan Gerrymandering after *LULAC v. Perry*," *Election Law Journal* 6 (1) (2007), and its references.

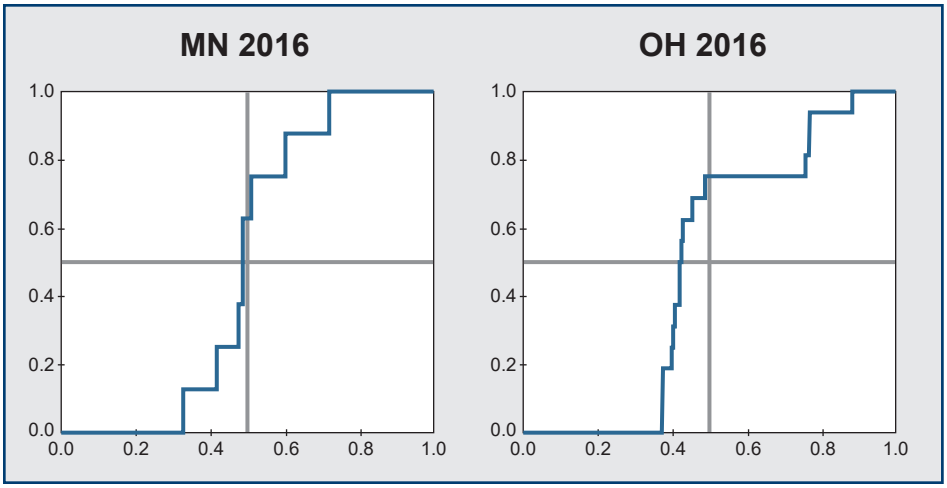


Figure 2. Seats-votes curves generated by uniform partisan swing from the Minnesota and Ohio congressional elections in 2016, both presented from the Republican point of view. The actual election outcomes from which the curves were derived are (0.48, 0.38) for Minnesota and (0.58, 0.75) for Ohio.

ceived the same vote share. That is, if Democrats received 60 percent of the vote and, with that, won 65 percent of the seats in the election, then if Republicans had earned 60 percent of the vote, they too should have received 65 percent of the seats.

To visualize this, let's build a *seats-votes plot*. On the *x*-axis we will record *V*, the proportion of votes won by party *A*. On the *y*-axis will be *S*, the proportion of seats in the electoral body won by *A*. So a single statewide election is represented by one point on this grid; for instance $(V, S) = (0.6, 0.65)$.

The problem is that a single data point does not tell you enough to understand the properties of the districting plan as a plan. A standard way to extend this point to a curve is to use the model called *uniform partisan swing*: look at the results district by district, and add/subtract the same number of percentage points to party *A*'s vote share in each district. As you keep adding to *A*'s vote share, you eventually push the share past 50 percent in some districts, causing those districts to flip their winner from *B* to *A*. And as you subtract, you eventually push districts toward *B*. Thus this method creates a curve that is step-shaped, showing a monotonic increase in the proportion of seats for *A* as the proportion of votes for *A* rises.

In Figure 2, we see that the Minnesota election has a seats-votes curve that is very nearly symmetric about the center point (0.5, 0.5). On the other hand, Ohio's curve is very far from symmetric. Rather, it looks like Ohio Republicans can secure 75 percent of the Congressional representation from just 50 percent of the vote, and that just 42 percent of the vote is enough for them to take a majority of the Congressional seats.

A partisan symmetry standard would judge a plan to be more gerrymandered for producing a more asymmetrical seats-votes curve, flagging a plan if the asymmetry is sufficiently severe. There are many ways that a mathematician could imagine using a bit of functional analysis to quantify the failure of symmetry, but there are also a few elementary and easy-to-visualize scores: for instance, look at how far the curve is from the center point (0.5, 0.5), either in vertical displacement or in horizontal displacement, on reasoning that any truly symmetric plan must award each party half the seats if the vote is split exactly evenly. Or compare one party's outcome with a given vote share to that for the other party if it had the same share.[5]

In the (substantial) literature on partisan symmetry scores, you will sometimes see the vertical displacement called *partisan bias*[6] and the horizontal displacement called the *mean/median score*.

Efficiency gap is a quite different idea about measuring partisan skew, both in its conceptual framing and in which plans it picks out as gerrymanders. However, it does have a whiff of symmetry about it: it begins with the normative principle that a plan is fair if the two parties "waste" an equal number of votes.

In order to parlay a certain given number of party *A* voters into the maximum possible number of seats for *A*, an extreme gerrymanderer would want to distribute *A* voters *efficiently* through the districts: you would win as many districts as you can by narrow margins, and you would not put any of your voters at all in the districts won by the other side, because they are not contributing toward your representation there. By this logic, there are two ways for a party to waste votes. On one hand, votes are wasted when there is an unnecessarily high winning margin – for this model, say every vote over 50 percent is wasted. On the other hand, all losing votes are wasted votes. Efficiency gap is the quantity given by the following simple expression: just add up the statewide wasted

5. If the seats-votes curve is denoted $f(V)$, then this comparison amounts to $P(V) = | f(V) - [1 - f(1 - V)] |$. It is natural, for instance, to evaluate this at $V = V_O$, the actual vote share in a given election, but most authors don't commit to this.

6. For example, Nick Stephanopoulos and Eric McGhee, "Partisan Gerrymandering and the Efficiency Gap," *University of Chicago Law Review* 82 (2) (2015): 831–900.

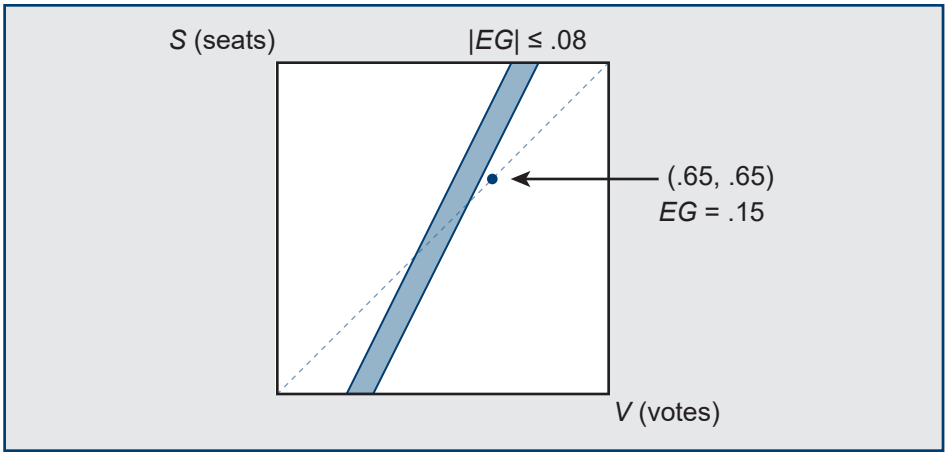


Figure 3. The region containing (*S*, *V*) outcomes that pass the *EG* test is shown in blue. The dashed line is direct proportionality (*S* = *V*).

votes for party *A* by summing over districts, subtract the statewide wasted votes for party *B*, and divide by the total number of votes in the state. Let's call this number *EG*. Note that it is a signed score, and that $-0.5 \leq EG \leq 0.5$ by construction.[7] By the logic of the definition, a totally fair plan would have $EG = 0$. This score was first devised by political scientist Eric McGhee and was made into the centerpiece of a multi-pronged legal test by McGhee and law professor Nick Stephanopoulos in their influential 2015 paper. For legislative races, they propose $|EG| = .08$ as the threshold, past which a plan would be presumptively unconstitutional.

Happily, this test is very easily represented on a seats-votes plot, such as we introduced previously.[8] The permissibility zone (derived from the *EG* formula and shown in Figure 3) turns out to be a strip of slope two in the seats-votes space; any election that produces an outcome falling outside this zone is flagged as a gerrymander. That the slope is two means that a certain "seat bonus" is effectively prescribed for the winning side: as the authors of the standard put it, "To produce partisan fairness, in the sense of equal wasted votes for each party, the bonus should be a precisely twofold increase in seat share for a given increase in vote share." This has the funny property that elections that produce directly proportional outcomes are often flagged as problematic.[9] For instance, the point (.65, .65), marked in the figure, where a party has earned 65 percent of the vote and converted it to 65 percent of the seats, is seen as a gerrymander in favor of the other side! Quantitatively, that is because this case has $EG = .15$, far larger than the threshold. Conceptually, it is because the party has received an inadequate seat bonus by the lights of the efficiency gap.

Finally, I want to sketch a new approach to redistricting analysis that has started to crystallize only in the last five or so years. It draws on a very well-established random walk sampling theory whose growth has accelerated continuously since its early development in the 1940s.[10] The scientific details for the application to gerrymandering are still coalescing, but the idea is incredibly promising and has profound conceptual advantages that should cause it to fare well in the courts. This idea is to use algorithmic sampling to understand the space of all possible districting plans for a given state.

Remember our goal: we seek to split up a large, finite graph into some number of districts. What you see in Figure 4 is a very small graph being split up into four districts, represented by the different colors. First, we constrain the search space with requirements for valid plans, such as contiguity of the pieces, compactness of their shapes, keeping population deviation under 1 percent, maintaining the current number of majority-minority districts, and so on. (This will depend on the laws in place in the state we are studying.[11]) A sampling algorithm takes a random walk around the space of all valid partitions: starting with a particular districting plan, flip units from district to district, thousands, millions, billions, or trillions of times.

Searching in this way, such as with a leading method called Markov Chain Monte Carlo, or MCMC, you can sample many thousands of maps from the chains produced by random flips. Each one is a possible way that you could have drawn the dis-

7. This is true because the total wasted votes in the state, and indeed in each district, add up to half of the votes cast.

8. Note that throughout this section we are leaning on the simplifying assumptions that all districts have equal turnout, there are only two parties, and all races are contested by both sides. These are varyingly realistic assumptions.

9. As mentioned above, *EG* is proposed as one part of a multi-pronged legal test, so high *EG* alone wouldn't doom a plan. But it is obviously still relevant to understand the systematic features of the score and the norms behind its construction.

10. Persi Diaconis's excellent survey, "The Markov Chain Monte Carlo Revolution," *Bulletin of the American Mathematical Society* 46 (2) (April 2009): 179–205, reviews successful applications of MCMC in chemistry, physics, biology, statistics, group theory, and theoretical computer science.

11. The process of interpreting and operationalizing rules to create scores certainly bears scrutiny. A successful implementation will have to demonstrate robustness of outcomes across choices made when scoring.

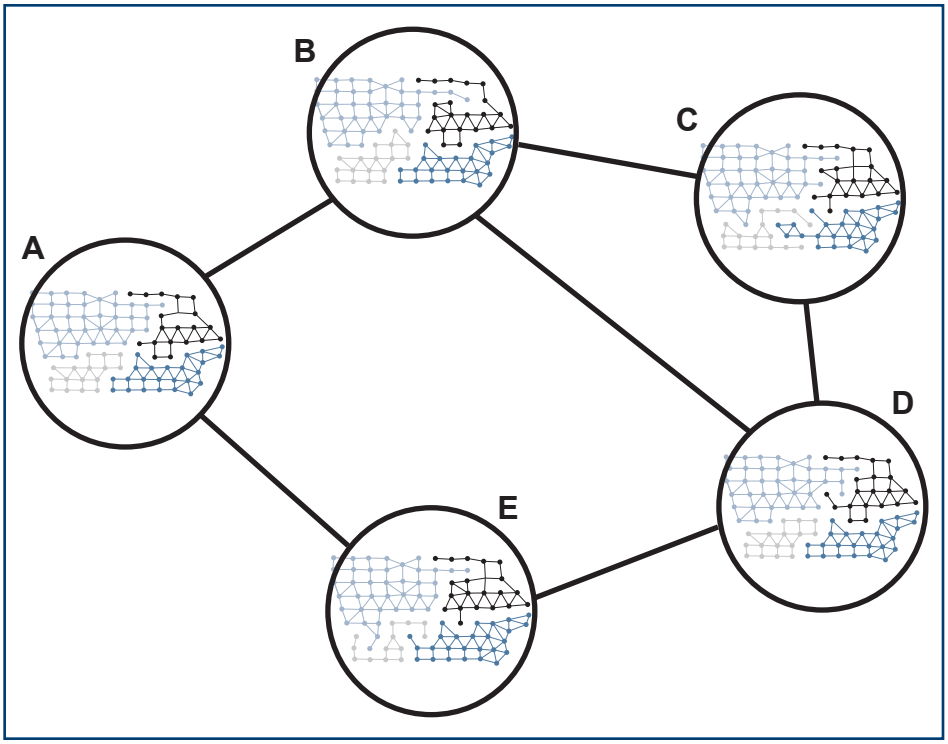


Figure 4. This figure shows a tiny section of a search space of districting plans. Two plans are adjacent here if a simple flip of a node from one district to another takes you from one plan to the other. For instance, toggling one node between light blue and black flips between plan *B* to plan *C*.

trict lines. Call this big collection of maps your *ensemble* of districting plans.

What can you do with a large and diverse ensemble of plans? This finally gives us a good way to address the baseline problem that always looms over attempts to adjudicate gerrymandering. That is, it gives us a tool we can use to decide whether plans are skewed relative to other possible plans with the same raw materials. The norm undergirding the sampling standard is that districting plans should be constructed *as though* just by the stated principles.

The computer sampling methods could even be used to craft a new legal framework: *Extreme outliers are impermissible* (see Figure 5). How extreme? That would require some time and experience to determine, just as population deviation standards have taken some time to stabilize numerically in response to the corresponding legal framework of *one person, one vote*.

The great strength of this method is that it is sensitive to the particularities, legal and demographic, of each state that it is used to analyze. If a state has specific rules in its constitution or in state law – examples include North Carolina's "whole county provision," Wisconsin's quirky rules for district contiguity, Arizona's preference for competitive races, incumbent protection in Kansas, and Colorado's guidance to minimize the sum of the district perimeters – the sampling can be carried out subject to those constraints or priorities. And just as importantly, it addresses a major critique that can be leveled at both of the previous approaches: why is it reasonable to prefer seats-votes symmetry, or to aim at equal vote wastage, when populations themselves are clustered in highly asymmetrical ways? For instance, imagine a state in which every household has three Republicans and two Democrats. (Of course, this is highly unrealistic, but it is an extreme case of a state with a very uniform distribution of partisan preferences.) Then no matter where you draw the lines, every single district will be 60 percent Republican, which means Republicans win 100 percent of the seats, corresponding to the point (.6, 1) on the seats-votes plot. One can easily verify that there is literally *no plan at all* that does not have a sky-high partisan bias[12] or that gets the efficiency gap below 0.3. On the other hand, the sampling method will reveal an ensemble in which all plans are made up of 60 – 40 districts, and thus will show a particular plan with that composition to be completely typical and therefore permissible along partisan lines. It seems intuitively unreasonable for 60 percent of the votes to earn all of the seats, but this method reveals that the political geography of this state demands it.

As mentioned earlier, these three approaches can be used in concert. For instance, one can use any evaluation axis with a sampling ensemble, say efficiency gap (or mean-median score) instead of partisan outcome. So you can mix and match these approaches. Nonetheless, each has a different normative principle at its core and they would produce quite different redistricting outcomes if they were to be adopted at the center of a new legal framework. Let's review some pros and cons.

12. In the simple model, the seats-votes curve is a step function with a big jump at $V = 1/2$. For more granularity, you could instead imagine a map in which one district has 39 percent Democrats and all others have percentages clustered around 41 percent, also producing a high partisan bias score for no very damning reason. Compare MN-2016 from Figure 2.

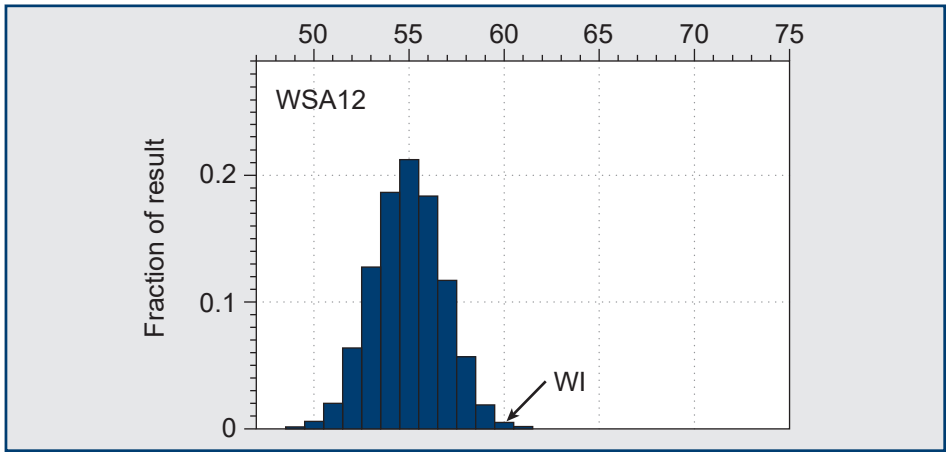


Figure 5. On this plot, the *x*-axis is the number of seats won by Republicans out of 99 in the Wisconsin State Assembly, and the *y*-axis shows how often each outcome occurred in the ensemble of 19,184 districting plans generated by the MCMC algorithm from Gregory Herschlag, Jonathan Mattingly, and Robert Ravier, ***Evaluating Partisan Gerrymandering in Wisconsin***, ArXiv. Given the actual vote pattern in the 2012 election, the plans could have produced a number of Republican seats anywhere from 49 to 61, with 55 seats being the most frequent outcome. The legislature's plan ("Act 43") in fact produced 60 seats for Republicans, making it more extreme than 99.5 percent of the alternatives.

For *partisan symmetry*, it is really easy to make the case for fairness: it sounds eminently reasonable that the two parties should be treated the same by the system. Partisan symmetry uses up-to-date statistics and political science and has a lot of professional consensus behind it. On the other hand, it has been critiqued by the Court as too reliant on speculation and counterfactuals, mainly because of how it arrives at conclusions on how a plan would have performed at different vote levels.[13] And it does not center on the question of how much advantage the line drawers have squeezed from their power, because it lacks a baseline of how much symmetry a politically neutral agent could reasonably be expected to produce, or even an agent who took symmetry as a goal. Crucially, it is not at all clear that it is easy or even feasible to draw a map that will maintain partisan symmetry across several elections in a Census cycle.

An interesting and attractive feature of *efficiency gap* is that it seems to derive, rather than prescribe, a permissible range in that seats/votes plot. It offers a single score and a standard threshold, and it is relatively easy to run.[14] The creators of the *EG* standard did about the best possible job of creating what the courts seemed to be demanding: a single judicially manageable indicator of partisan gerrymandering. It is just important not to elevate *EG* as a stand-alone metric, since it is trying to address a fundamentally multidimensional problem.

Finally, I have described the *sampling* approach and *outlier analysis*, and I have argued that the strength of this approach is that it is sensitive to not only the law, as we have seen, but also to the political geography of each state – for instance, Wisconsin Democrats are densely arranged in Milwaukee proper, ringed by heavily Republican suburbs, but in Alaska Democrats are spread throughout the rural parts of the state – which might have hard-to-measure effects on just how possible it is to split up the votes symmetrically or efficiently. Outlier analysis does not measure a districting plan against an all-purpose ideal, but against actual splittings of the state, holding the distribution of votes constant. In the next ten years, I expect to see explosive scientific progress on characterizing the geometry and topology of the space of districting plans, and on understanding the sampling distributions produced by our algorithms.

Note: Many thanks to the American Academy of Arts and Sciences; the other panelists: Gary King and Jamal Greene; and the moderator, Chief Judge Patti Saris. Thanks also to Asaf Bar-Natan, Mira Bernstein, Rebecca Willett, and the research team of Jonathan Mattingly, whose images are reproduced here with permission. I am grateful to Mira Bernstein, Justin Levitt, and Laurie Paul for feedback. ■

To view or listen to the presentations, visit https://www.amacad.org/redistricting.

13. As Justice Kennedy wrote, "The existence or degree of asymmetry may in large part depend on conjecture about where possible vote-switchers will reside. Even assuming a court could choose reliably among different models of shifting voter preferences, we are wary of adopting a constitutional standard that invalidates a map based on unfair results that would occur in a hypothetical state of affairs." *LULAC v. Perry* 126 S. Ct. 2594 (2006).

14. The small print for efficiency gap: you have to worry about which election data to use, and how to impute outcomes in uncontested races, which leaves a little bit of room for the possibility of dueling experts, but by and large it is a very manageable standard.

Commission on the Future of Undergraduate Education

The Future of Undergraduate Education, The Future of America

Following two years of sustained deliberations grounded in reviews of innovative practices, policies, and studies and informed by meetings with state and federal policy-makers, students and faculty members, and experts from around the country, the Commission on the Future of Undergraduate Education released its final report – *The Future of Undergraduate Education, The Future of America* – in late November 2017. In the report, the Commission offers a comprehensive national strategy to improve undergraduate education that encompasses three broad recommendations:

1. Ensure that all students have high-quality educational experiences;
2. Increase overall completion rates and reduce inequities among different student populations at every level of undergraduate education;
3. Manage college costs and improve the affordability of undergraduate education.

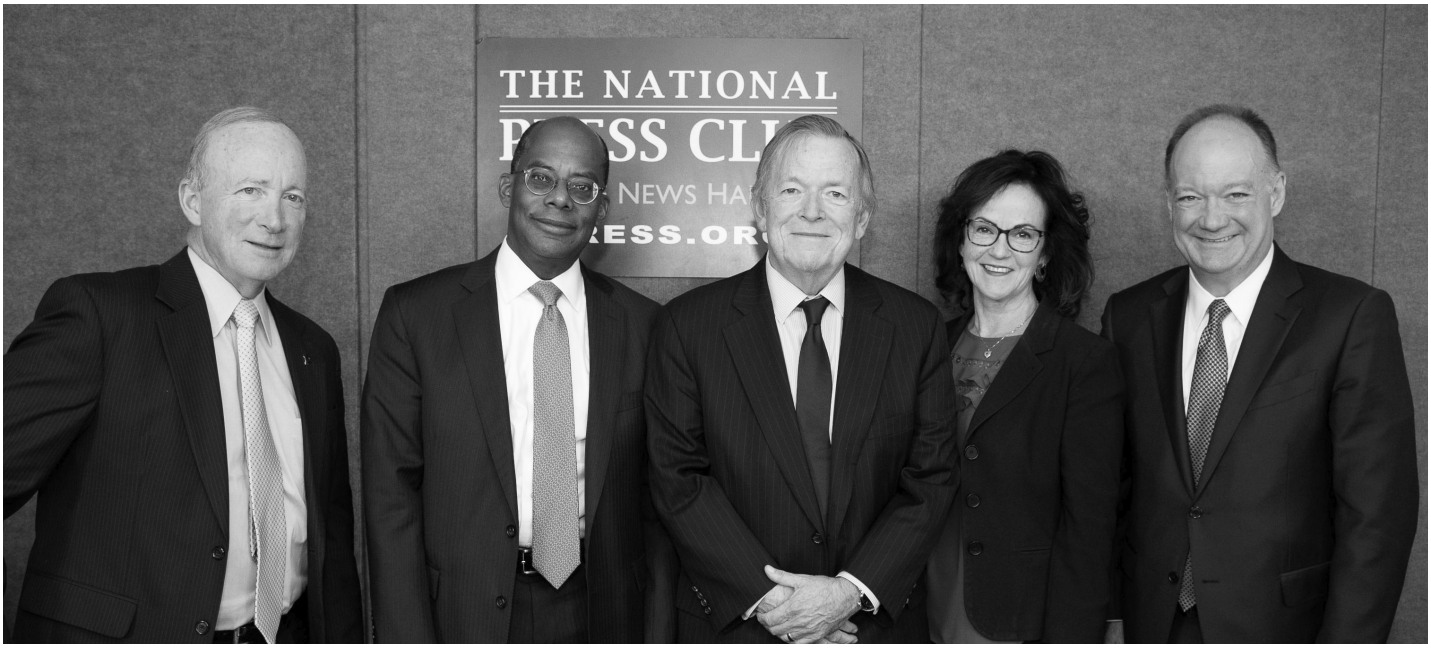
In the final section of the report, the Commission takes a more speculative approach, looking to the future through the lens of several factors, including the country's level of social cohesion; the characteristics of the workforce; the level of access to information and educational technologies; and unforeseen natural or human-generated global challenges.

The Academy hosted a series of events in New York and Washington, D.C., to announce the release of *The Future of Undergraduate Education, The Future of America* and to gain Congressional and national attention and support. Over the course of the rollout week, the Academy convened Commissioners, members, project contributors, policy-makers, and partners at events that included:

- A well-attended official report release and public symposium at the National Press Club in Washington, D.C. The panelists included Academy President Jonathan Fanton, Commission Co-chairs Roger Ferguson (TIAA) and Michael McPherson (formerly, Spencer Foundation), and Commissioners Mitchell Daniels (Purdue University), Deborah Ball (University of Michigan), and John DeGioia (Georgetown University).
- Meetings with federal policy-makers, including Under Secretary of Education James Manning and twenty-one Members of Congress and/or their key legislative advisors. The Commission met with twelve Democrats and nine Republicans: eleven from the Senate and ten from the House of Representatives.
- A working lunch with leaders from major Washington, D.C., based higher education associations, including the Association of American Universities, the National Association of Independent Colleges and Universities, the American Association of State Colleges and Universities, the American Association of Community Colleges, the Association of Public and Land-grant Universities, the Council of Independent Colleges, the Association of American Colleges and Universities, and the Aspen Institute.
- An Academy Stated Meeting and panel discussion in New York, featuring Vartan Gregorian (Carnegie Corporation of New York) and Commissioners Michael McPherson, Gail Mellow (LaGuardia Community College), and Nicholas Lemann (Columbia University).
- A dinner for Academy members hosted by Steven Knapp (George Washington University) and the Academy's Local Program Committee in Washington, D.C. The program featured remarks by Commissioners Rebecca Blank (University of Wisconsin-Madison) and Nicholas Lemann.

Coverage of the release of the final report included articles in *The Chronicle of Higher Education*, *Inside Higher Education*, and other media; radio interviews on *WAMU* and *WGBH News*; and an event sponsored by *The Wall Street Journal* that featured Cochair Roger Ferguson, who spoke about the future of higher education. To read these articles and listen to or watch the interviews, please visit the Commission's website at www.amacad.org/cfue. An electronic version of the final report and supporting publications are also available on the website.

The Academy will continue to engage in a variety of outreach activities throughout 2018 to advance the recommendations in the



Mitchell Daniels (Purdue University), **Roger Ferguson, Jr.** (TIAA), **Michael McPherson** (formerly, Spencer Foundation), **Deborah Ball** (University of Michigan), and **John DeGioia** (Georgetown University)

final report around quality, completion, and affordability. Plans are currently underway for statewide meetings in Wisconsin and Kentucky, involving leaders from private and public colleges and universities and from business and industry, as well as state legislators. Statewide events in Minnesota, Nevada, and California, among other states, are in development.

To extend the dialogue and advance the report's recommendations, several Commissioners will be speaking at upcoming conferences. Commission Cochair Michael McPherson will give a talk at the Association of American Colleges and Universities' annual meeting; Commissioner J. Michael Locke (formerly, Rasmussen Inc.) will moderate a discussion about the report at the Arizona State University + Global Silicon Valley Summit; and the final report will be a major focus at TIAA's annual client forum in April, which attracts hundreds of higher education leaders from around the country

In addition, Mark Zandi (Moody's Analytics) spoke at the Brookings Institution's Forum on the Future of Higher Education about an occasional paper his team authored for the Commission on *The Economic Impact of Increasing College Completion*. Their analysis indicates that an ambitious yet achievable improvement in college completion rates would require substantial investments over a decade and more, but the longer-term effect would be a significant improvement in the productivity of the American economy and a resultant gain in the nation's standard of living.

Additional outreach activities are being planned, such as convening members of the Academy's Affiliates Program, which includes sixty-five colleges and universities from around the country, to explore the themes and recommendations in the report; holding small meetings with business leaders who have a strong interest in strengthening undergraduate education; and working with the Academy's Local Program Committees to feature the work of the Commission at their meetings. The Commission will be developing additional content and publications to further the national dialogue, including report briefs for state policy-makers and higher education institutions that feature top recommendations and a forthcoming issue of *Dædalus* on higher education, which will be published in fall 2019.

To evaluate the extent to which these outreach efforts are successful in advancing the report's recommendations, Academy staff and Commission members are discussing indicators that could be monitored over the next five years as a way of understanding the country's success in improving undergraduate education. Such indicators include the adoption of new teacher training initiatives in graduate programs; new institutional efforts to improve student completion rates; and, at the federal level, the adoption of a single,

The Future of Undergraduate Education, The Future of America **reflects the Commission's highest ideals: that every person, from every background, can succeed in America when given the proper training and preparation; that the country's existing institutions of undergraduate education can and will evolve to meet the needs of today's students; and that the free exchange of ideas is the basis of a creative, productive, and democratic society.**

income-driven repayment plan that automatically enrolls students and collects loan payments through the income tax system. More broadly, the Commission will monitor national completion rates and student loan repayment rates.

The Future of Undergraduate Education, The Future of America reflects the Commission's highest ideals: that every person, from every background, can succeed in America when given the proper training and preparation; that the country's existing institutions of undergraduate education can and will evolve to meet the needs of today's students; and that the free exchange of ideas is the basis of a creative, productive, and democratic society.

The first set of recommendations included in the report focuses on ensuring that all students – whatever their program of study – have high-quality educational experiences that prepare them for success in the twenty-first century.

The report notes that much of the current public discourse about higher education focuses on two systemic challenges: the affordability of a degree and the importance of program completion. But what kind of education is worth students' commitment of time and their investment of scarce resources? Too little attention has been devoted to this question and to the rigors of the learning experience itself. The Commission believes that some important general characteristics distinguish a quality college education, including the quality of the teaching students encounter. Completion and affordability are critical challenges, but completion and affordability for what?

The Commission recommends that there should be a greater emphasis in undergraduate education on the educational experience itself and, in particular, on the challenge of ensuring that the seventeen million diverse college students, enrolled in many types of programs, are learning and mastering knowledge, skills, and dispositions that will help them succeed in the twenty-first-century United States. Today's students face the growing challenges of a changing and more competitive global economy in which they are competing against highly motivated and trained students from around the world. The final report, therefore, focuses first on recommendations that strengthen the student educational experience and student learning. All college graduates – regardless of their major or the credential they will earn – need their programs of study to impart a forward-looking combination of academic knowledge and practical skills so they are prepared for both economic success and civic engagement. The long-standing debate today over the value of a liberal arts education versus a more applied postsecondary program presents a false choice. College educators need to adjust their program curricula and learning expectations accordingly. And students need to see that the ability to work and learn with others, and to disagree and debate respectfully, is a skill essential for a high quality of life, a future of economic success, and effective democratic citizenship.

Hilary Pennington (Ford Foundation), **Senator Tammy Baldwin**, and **Rebecca Blank** (University of Wisconsin-Madison)

The Commission recognizes that advancing the broad learning agenda advocated here – and encouraging more attention be paid to the teaching enterprise itself – will remain difficult until more sophisticated and useful ways of measuring what students actually learn are developed. Redressing the lack of good data is a high priority. The Commission calls for far greater attention to and support for the quality of college teaching and the teaching workforce. Students learn in many different settings, including through peer interactions, co- and extracurricular activities, and self-motivated exploration. Ultimately, though, making undergraduate learning stronger and more rigorous will depend upon how undergraduate education invests in the teaching skills of its faculty and the kinds of institutional and systemic commitments that are made.

The Future of Undergraduate Education, The Future of America concludes with the following observations: There is a long-standing debate about whether undergraduate education is a private good, serving the needs of individuals, or a public good, meeting larger civic and community needs. The answer, the Commission is convinced, is that undergraduate education is both a public and a private good. Those who invest in an education are consistently rewarded with higher earnings and more stable employment – both important private benefits. In recent decades, the earnings advantage for college graduates has been higher, on average, than ever before. The Commission's primary goal in writing the report has been to help guide the next stage in the evolution of American undergraduate education, in which all students can afford, complete, and enjoy the benefits of the education they seek when they enroll, an education that truly prepares them for life in the twenty-first century. But beyond the benefits to individuals, there are real public benefits of undergraduate education.

The Commission has identified a profound role that undergraduate education can and indeed must play for the sake of the nation's future. America is polarized by race, class, and political and religious convictions, among other ways. And yet as we acknowledge and respect difference, we must find opportunities to knit people and communities together in terms of equality and mutual respect. Although this is not a problem that undergraduate education can "solve," colleges and universities are among the few American institutions in which significant numbers of people from different backgrounds and communities come together for a shared purpose. Although divisions may sometimes produce painful and risky confrontations, they can also create opportunities to build relationships and further mutual understanding. This is, in the Commission's view, a core component of education and a crucial element for the nation's civic and political future.

Jonathan Fanton (American Academy) and **Steven Knapp** (George Washington University)

We face huge challenges. Yet the reasons for optimism are real. The country's colleges and universities have a greater reach across the population than ever before. For all the challenges and tensions evident on many of today's campuses, we must remember that the long-run trend on campuses has been toward more diversity and inclusion. We harbor no doubts about the value and benefits of a quality college education – it delivers on its promises of greater individual and social prosperity. We are hopeful because more and more colleges are learning how to help students succeed in moving to complete their programs and are developing effective practices that other colleges can emulate. We are hopeful because there are real financial changes and technological opportunities that, if enacted smartly, can further facilitate student success. Progress is not guaranteed, and good things will happen only with sustained effort, but if we combine patience with urgency, we can, through undergraduate education, make great advances as individuals and as a nation. ■

Not by Earnings Alone: A New Academy Report on College Graduates in the Workforce

While much of the conversation about the value of a college degree tends to focus on graduates' earnings, a new report from the American Academy of Arts and Sciences' Humanities Indicators offers a more expansive view. Drawing largely on original research using federal data sets and the Gallup-Purdue Index survey of college alumni, the new report – *Graduates in the Workforce & Beyond* – finds that college graduates with degrees from fields with below-average earnings (such as education and the humanities) are quite similar to graduates from other fields with respect to their *perceived* well-being.

Often the value of a college degree is assessed in economic terms. The Humanities Indicators newest report details the median earnings for those with undergraduate degrees in each of the major fields of study, with comparative data on the income differences for women and for those who earn advanced degrees. As the report notes, in 2015 graduates with engineering degrees had the highest median earnings ($82,000), while those with undergraduate degrees in education had the lowest ($44,000). Humanities majors, the principal subject of the report, had median earnings of $52,000.

The report also notes substantial differences among college degree recipients related to factors other than the field of degree. For instance, obtaining an advanced degree makes a clear difference in the earnings of college graduates: the median earnings of those who went on to earn an advanced degree (in any field) were 38 percent higher than those without an advanced degree. Unfortunately, gender also appears to make a substantial difference in graduates' subsequent earnings. Across all fields, women with college degrees earned an average of 28 percent less than their male counterparts if they had only a bachelor's degree, and an average of 31 percent less if they held an advanced degree.

The differences in average earnings are often cited in association with rising concerns about growing levels of student debt, with many assuming that majors with lower average earnings suffer more acutely from the problem. A new analysis of debt levels among college graduates as of 2015, however, shows only negligible differences between humanities and non-humanities graduates across all age cohorts. For example, 45 percent of humanities graduates aged 35 to 54 carried no college debt, as compared to 43 percent of graduates from all fields (see Figure 1). Among those aged 55 and older, the share was 65 percent for both humanities and non-humanities graduates. The shares of college graduates with more than $10,000 in debt were similarly close in each age cohort.

The report also examines how graduates from the humanities, professional, and scientific fields feel about their jobs and their lives more generally. On these measures, the new data tend to find similarities rather than differences (though it is notable that even though they have the lowest median earnings, college graduates

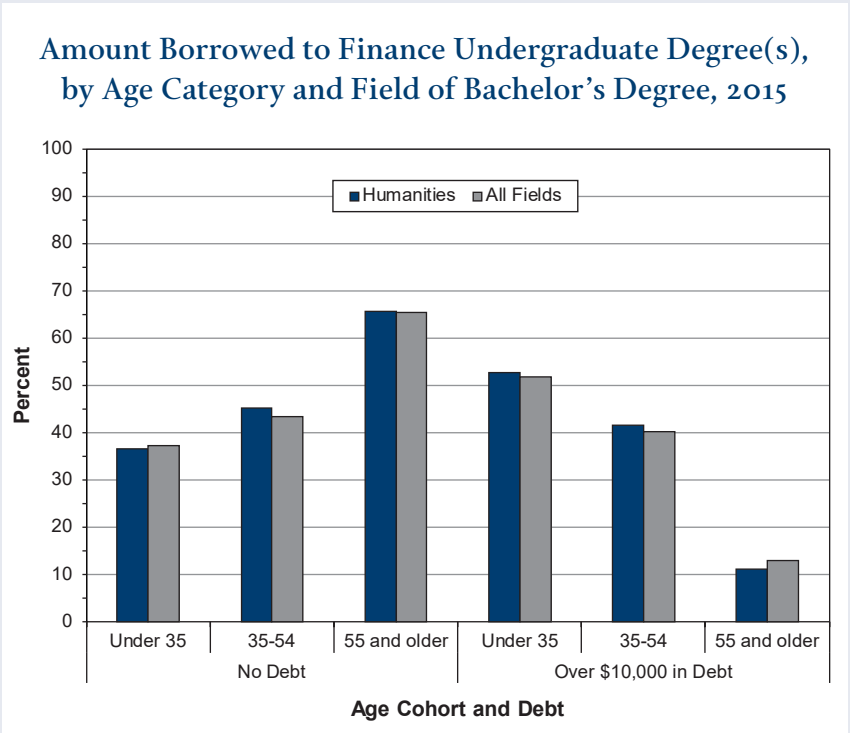


Figure 1 Source and details at http://humanitiesindicators.org.

Bachelor's Degree Holders' Financial Satisfaction, by Field of Bachelor's Degree, 2014

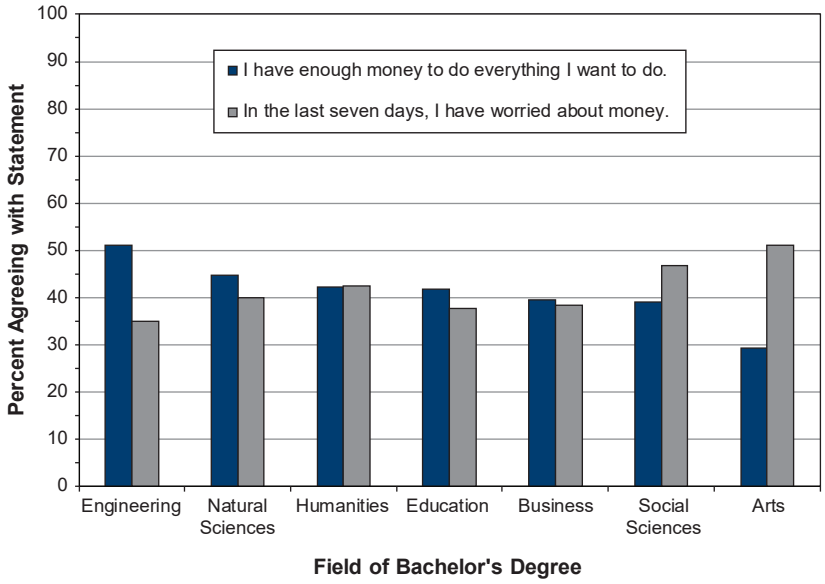


Figure 2

Source and details at http://humanitiesindicators.org.

with education degrees generally report the highest levels of satisfaction with their jobs on a wide variety of metrics).

Almost 87 percent of workers with a bachelor's degree reported they were satisfied with their jobs in 2015, with only a modest difference between the fields. On another measure of job satisfaction, around 80 percent of graduates who had majored in either education or the natural sciences reported "I am deeply interested in the work I do" and that "I have the opportunity to do what I do best every day." In comparison, engineering and humanities graduates were closer to 70 percent on the same measures.

When asked about their satisfaction with a range of intangible aspects of their jobs, more than 80 percent of college graduates reported they were satisfied with the intellectual challenge of their jobs and their contribution to society, and almost 90 percent reported satisfaction with their level of responsibility and the degree of independence in their jobs. Graduates from education and the health and medical sciences typically had the highest levels of satisfaction with these aspects of their jobs.

Beyond perceptions, the report also highlights similarities between the majors in the kinds of work performed at their jobs. The analysis finds that more than a million graduates with bachelor's degrees in the humanities were employed as managers in 2015, and almost 60 percent of humanities graduates report managing or supervising employees as part of their job (which was equal to the percentage for all graduates).

The report looks beyond the workforce, to graduates' feelings about their lives in general. Given the wide disparities in earnings between engineers and graduates from other fields, one might expect a wide gap in their relative sense of financial comfort. Here again, the gap was relatively narrow. As of 2014, only 51 percent of engineering graduates reported that "I have enough money to do everything I want to do." (see Figure 2) Among humanities and education graduates, the share was 42 percent. Despite substantial differences in median earnings, the share of humanities graduates who had recently worried about money was close to the shares of graduates from the natural sciences, education, and business who had experienced the same anxiety.

Perceived Relationship between Job and Degree, by Field of Bachelor's Degree, 2015

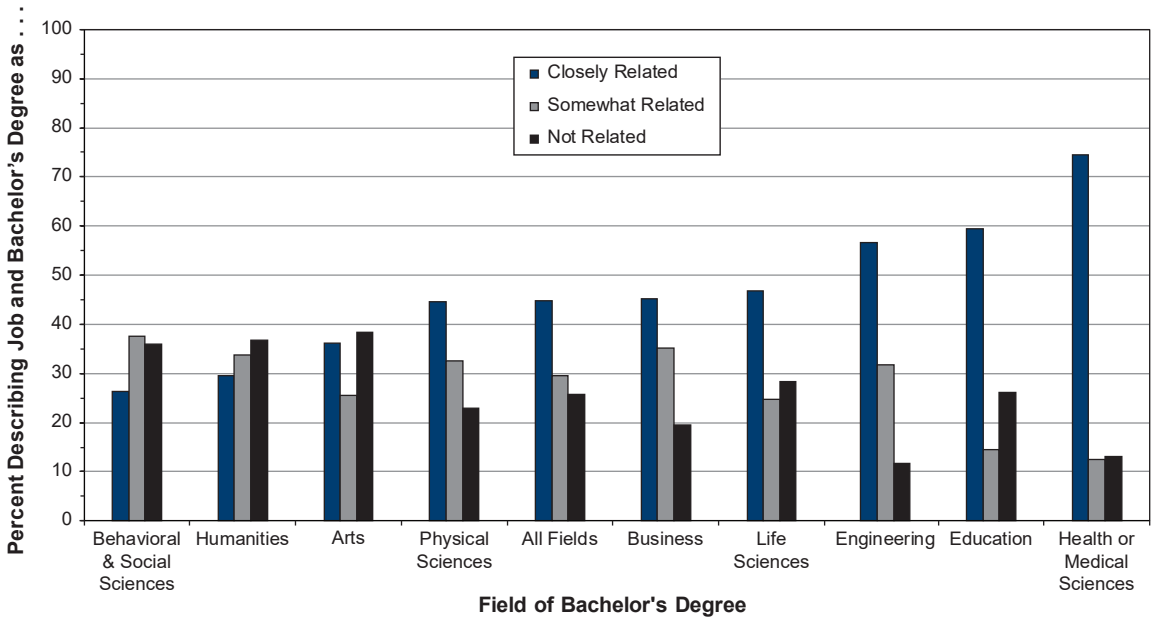


Figure 3

Source and details at http://humanitiesindicators.org.

A new tabulation of the 2014 Gallup-Purdue Index survey of college alumni found only modest differences among majors with respect to the share who believed that they had or soon would realize their "best possible" life. At the time of the survey, over three-quarters of humanities graduates saw themselves as at least 70 percent of the way to this goal, which was similar to the shares of engineering and natural science graduates who believed the same thing. Education majors were the most likely to feel they were close to attaining such a life. In every field, an even larger share of respondents expected to be well on their way to their best life or to have attained that life in five years. Ninety percent of graduates from every other field reported similar levels of optimism about their prospects in the future.

The report notes a substantial difference between scholarly disciplines and professional fields on one metric: less than 30 percent of graduates with bachelor's degrees in the humanities and social sciences felt that their job was closely related to their degree, while more than a third saw no relationship. Graduates who had majored in business, education, and the health sciences were much more likely to view their degree and work as closely related (see Figure 3).

Graduates in the Workforce & Beyond reflects a set of updates to items about undergraduate earnings and employment outcomes recently published on the Humanities Indicators site, which provide more detailed analyses of differences between the fields.

For more information about the Humanities Indicators, including analyses of data for non-humanities fields, please visit www.humanitiesindicators.org or contact the Indicators staff at rtownsend@amacad.org. ■

Select Prizes and Awards to Members

Nobel Prize in Chemistry, 2017

Joachim Frank (Columbia University)

Nobel Prize in Economic Sciences, 2017

Richard H. Thaler (University of Chicago)

Nobel Prize in Literature, 2017

Kazuo Ishiguro (London, United Kingdom)

Nobel Prize in Physics, 2017

Barry C. Barish (California Institute of Technology)

Kip S. Thorne (California Institute of Technology)

Rainer Weiss (Massachusetts Institute of Technology)

Nobel Prize in Physiology or Medicine, 2017

Jeffrey C. Hall (Cambridge, Maine; Brandeis University)

Michael Rosbash (Brandeis University)

Other Awards

James Roger Angel (University of Arizona) has been named a Fellow of the National Academy of Inventors.

Joseph E. Aoun (Northeastern University) is the recipient of a 2017 Academic Leadership Award, given by Carnegie Corporation of New York.

Charles L. Bennett (Johns Hopkins University) was awarded the Breakthrough Prize in Fundamental Physics.

Andrea Bertozzi (University of California, Los Angeles) was selected as a 2017 Simons Investigator by the Simons Foundation.

Clara D. Bloomfield (Ohio State University) is the recipient of the 2017 Robert A. Kyle Award for Outstanding Clinician-Scientist, presented by the Mayo Clinic Division of Hematology.

Emmanuel J. Candès (Stanford University) was named a 2017 Fellow of the John D. and Catherine T. MacArthur Foundation.

Joanne Chory (Salk Institute for Biological Studies) was awarded the Breakthrough Prize in Life Sciences.

Don W. Cleveland (University of California, San Diego) was awarded the Breakthrough Prize in Life Sciences.

Max D. Cooper (Emory University) was awarded the 2018 Japan Prize in Medical Science and Medicinal Science.

France Cordova (National Science Foundation) was inducted into the U.S. News STEM Leadership Hall of Fame.

Thibault Damour (Institut des Hautes Études Scientifiques) was awarded a Gold Medal by the National Center for Scientific Research (CNRS) in France.

John J. DeGioia (Georgetown University) is the recipient of a 2017 Academic Leadership Award, given by Carnegie Corporation of New York.

Titia de Lange (Rockefeller University) received the 47th Lewis S. Rosenstiel Award for Distinguished Work in Basic Medical Research, given by Brandeis University.

Joseph DeSimone (University of North Carolina at Chapel Hill; North Carolina State University) received the 22nd Heinz Award in Technology, the Economy, and Employment.

Michael Dine (University of California, Santa Cruz) was awarded the J.J. Sakurai Prize for Theoretical Physics by the American Physical Society.

James R. Downing (St. Jude Children's Research Hospital) was awarded the 2017 E. Donnall Thomas Lecture and Prize by the American Society of Hematology.

Carol Dweck (Stanford University) was awarded the inaugural Yidan Prize.

Felton Earls (Harvard University) is the recipient of the 2018 Sarah Gund Prize for Research and Mentoring in Child Mental Health, awarded by the Child Mind Institute. He also received the 2017 Professor Emeriti Award from the Harvard T. H. Chan School of Public Health.

Elazer Edelman (Massachusetts Institute of Technology) received the Transcatheter Cardiovascular Therapeutics 2017 Career Achievement Award.

Jonathan A. Epstein (University of Pennsylvania Perelman School of Medicine) received an Outstanding Investigator Award from the National Heart, Lung, and Blood Institute.

Paul Farmer (Harvard Medical School; Brigham and Women's Hospital; Partners in Health) was awarded the 2018 Public Welfare Medal from the National Academy of Sciences.

Robert Full (University of California, Berkeley) was named a Howard Hughes Medical Institute Professor.

Shafi Goldwasser (Massachusetts Institute of Technology) was named a Fellow of the Association for Computer Machinery.

Jeffrey I. Gordon (Washington University School of Medicine in St. Louis) received the Sanofi-Institut Pasteur International Award.

Jorie Graham (Harvard University) was awarded the Wallace Stevens Award, given by the Academy of American Poets.

Peter Grant (Princeton University) and **Rosemary Grant** (Princeton University) are the recipients of the BBVA Foundation Frontiers of Knowledge Award in the Ecology and Conservation Biology category.

Barbara Grosz (Harvard University) is the recipient of the Lifetime Achievement Award of the Association for Computational Linguistics.

Christopher Hacon (University of Utah) was awarded the Breakthrough Prize in Mathematics.

Naomi Halas (Rice University) was awarded the 2018 Julius Edgar Lillienfeld Prize by the American Physical Society.

John L. Hennessy (Stanford University) was elected an International Fellow of the Royal Academy of Engineering.

Wayne Hu (University of Chicago) was selected as a 2017 Simons Investigator by the Simons Foundation.

John Jeffries (University of Virginia School of Law) received the Thomas Jefferson Award from the University of Virginia.

Marc Kamionkowski (Johns Hopkins University) was elected a Fellow of the American Association for the Advancement of Science.

Robert Keohane (Princeton University) was awarded the 2016 Balzan Prize for International Relations, History, and Theory.

Maria Klawe (Harvey Mudd College) is the recipient of a 2017 Academic Leadership Award, given by Carnegie Corporation of New York.

Lynne Maquat (University of Rochester) is the recipient of the 2018 FASEB Excellence in Science Award, given by the Federation of American Societies of Experimental Biology. She was also awarded the 2017 Vanderbilt Prize in Biomedical Science, given by Vanderbilt University School of Medicine.

Margaret McFall-Ngai (University of Hawai'i at Manoa) was named a Howard Hughes Medical Institute Professor.

Barbara J. McNeil (Harvard Medical School) received the Walsh McDermott Medal from the National Academy of Medicine.

Daniel Mendelsohn (New York, New York) was awarded Princeton University's James Madison Medal.

Silvio Micali (Massachusetts Institute of Technology) was named a Fellow of the Association for Computer Machinery.

Paul Milgrom (Stanford University) is the recipient of the 2017 CME Group-MSRI Prize in Innovative Quantitative Applications.

Toshiko Mori (Toshiko Mori Architect; Harvard University Graduate School of Design) is the recipient of the 2018 Maine in America Award, given by the Farnsworth Art Museum.

Paul Muldoon (Princeton University) was awarded The Queen's Gold Medal for Poetry for 2017.

Kim Nasmyth (University of Oxford) was awarded the Breakthrough Prize in Life Sciences.

Eric J. Nestler (Icahn School of Medicine at Mount Sinai) was awarded the American College of Neuropsychopharmacology Paul Hoch Distinguished Service Award and the Wilbur Cross Medal from the Yale Graduate School of Arts and Sciences.

William Nordhaus (Yale University) received the BBVA Foundation Frontiers of Knowledge Award.

Michel Nussenzweig (The Rockefeller University) received the Sanofi-Institut Pasteur International Award.

Onora O'Neill (University of Cambridge) was awarded the 2017 Berggruen Prize for Philosophy & Culture.

Lyman Page, Jr. (Princeton University) was awarded the Breakthrough Prize in Fundamental Physics.

Henry Samueli (Broadcom Corporation) was inducted into the U.S. News STEM Leadership Hall of Fame.

George Saunders (Syracuse University) was awarded the Man Booker Prize for *Lincoln in the Bardo*.

Helmut Schwarz (Technische Universität Berlin) was elected a Foreign Member of the Russian Academy of Natural Sciences.

Michelle Simmons (University of New South Wales) was named the 2018 Australian of the Year.

Michael Sipser (Massachusetts Institute of Technology) was named a Fellow of the Association for Computer Machinery.

David N. Spergel (Princeton University) was awarded the Breakthrough Prize in Fundamental Physics.

Raymond Stata (Analog Devices, Inc.) is the recipient of the 2017 Dr. Morris Chang Exemplary Leadership Award, given by the Global Semiconductor Alliance.

Natasha Trethewey (Northwestern University) is the recipient of the 22nd Heinz Award in the Arts and Humanities.

Andrew J. Viterbi (Viterbi Group) has been named a Fellow of the National Academy of Inventors.

Darren Walker (Ford Foundation) was awarded the W.E.B. Du Bois Medal from Harvard University.

Kara Walker (Columbia University) was awarded the W.E.B. Du Bois Medal from Harvard University.

Peter Walter (University of California, San Francisco) was awarded the Breakthrough Prize in Life Sciences.

Carl Wieman (Stanford University) was named a Howard Hughes Medical Institute Professor.

New Appointments

Aigboje Aig-Imoukhuede (Nigerian Stock Exchange; Africa Initiative for Governance) was appointed to the International Advisory Board of the Blavatnik School of Government, University of Oxford.

Graeme I. Bell (University of Chicago) has been appointed to the Board of Directors of Pascal Biosciences, Inc.

Philip Bucksbaum (Stanford University) has been elected Vice President of the American Physical Society.

Thomas P. Campbell (Metropolitan Museum of Art) has been elected a member of the Board of the Broad Museum in Los Angeles.

Kenneth I. Chenault (American Express) has been named Chairman and Managing Director of General Catalyst Partners.

Steven Chu (Stanford University) has been selected as President-Elect of the American Association for the Advancement of Science.

Johnnetta B. Cole (Smithsonian Institution) has been named a Senior Consulting Fellow of The Andrew W. Mellon Foundation.

Michael V. Drake (Ohio State University) was elected Chair of the Board of Directors of the Association of American Universities.

Fred H. Gage (Salk Institute for Biological Studies) has been appointed to the Scientific Advisory Board of Presto Therapeutics.

Shafi Goldwasser (Massachusetts Institute of Technology) has been appointed Director of the Simons Institute for the Theory of Computing at the University of California, Berkeley.

John L. Hennessy (Stanford University) has been named Executive Chairman of Alphabet.

David Ho (Rockefeller University) has been appointed to the Scientific Advisory Board of WuXi Biologics.

Mellody Hobson (Ariel Investments) has been appointed to the Board of Trustees of The Rockefeller Foundation.

Randy H. Katz (University of California, Berkeley) has been appointed Vice Chancellor for Research at the University of California, Berkeley.

Sherry Lansing (Sherry Lansing Foundation) has been elected a member of the Board of the Broad Museum in Los Angeles.

Ann L. Lee (Genentech; Roche) has been appointed Executive Vice President of Technical Operations of Juno Therapeutics, Inc.

Judy Lewent (Merck & Company) has been appointed to the Business Advisory Board of twoXAR, Inc.

Monica Lozano (University of California Board of Regents) has been named President and CEO of College Futures Foundation.

Robert Malenka (Stanford University) has joined Cerevance as a Senior-Level Scientific Advisor.

Barbara J. McNeil (Harvard Medical School) was elected Chair of the Grants Committee of the Warren Alpert Foundation.

Michael S. McPherson (formerly, Spencer Foundation) has been named a Senior Fellow of The Andrew W. Mellon Foundation.

Mona Nemer (University of Ottawa) was named Canada's Chief Science Advisor.

Susan Packard Orr (David and Lucille Packard Foundation) has been elected to the Board of Directors of the National Audubon Society.

Roger M. Perlmutter (Merck Research Laboratories) has been appointed to the Board of Directors of Exonics Therapeutics, Inc.

Sharon Percy Rockefeller (WETA) has been appointed to the Board of Trustees of The Rockefeller Foundation.

Peter Schultz (Scripps Research Institute) has been appointed to the Scientific Advisory Board of WuXi Biologics.

Ruth J. Simmons (Brown University) was named President of Prairie View A&M University.

James Stavridis (Tufts University) has been appointed to the Board of Trustees of The Rockefeller Foundation.

Luis A. Ubiñas (New York, New York) has been appointed to the Board of Directors of Boston Private Financial Holdings, Inc.

Meg Whitman (Hewlett Packard Enterprise Co.) has been named Chief Executive of NewTV.

Janet Yellen (United States Federal Reserve) has been named a Distinguished Fellow at the Hutchins Center of Fiscal and Monetary Policy at the Brookings Institution.

Maria Zuber (Massachusetts Institute of Technology) has been appointed to the Board of Directors of the Bank of America.

Select Publications

Poetry

David Ferry (Wellesley College), trans. *The Aeneid*. University of Chicago Press, September 2017

Carl Phillips (Washington University in St. Louis). *Wild Is the Wind*. Farrar, Straus and Giroux, January 2018

Fiction

James Carroll (Boston, Massachusetts). *The Cloister*. Doubleday/Talese, March 2018

Anne Carson (McGill University). *Bakkhai*. New Directions, December 2017

Thomas Keneally (Manly, Australia). *Crimes of the Father*. Atria, October 2017

James McBride (New York University). *Five-Carat Soul*. Riverhead Books, September 2017

Sigrid Nunez (New York, New York). *The Friend*. Riverhead, February 2018

Laurence Senelick (Tufts University). A translation of Georges Feydeau, *From Marriage to Divorce: Five Farces of Marital Discord*. Broadway Play Publishers, August 2017

Nonfiction

Danielle Allen (Harvard University). *Cuz: The Life and Times of Michael A*. Liveright, September 2017

Martin Amis (Brooklyn, New York). *The Rub of Time: Bellow, Nabokov, Hitchens, Travolta, Trump: Essays and Reportage, 1994 – 2017*. Knopf, February 2018

Edward L. Ayers (University of Richmond). *The Thin Light of Freedom: Civil War and Emancipation in the Heart of America*. W.W. Norton, October 2017

John Banville (Dublin, Ireland). *Time Pieces: A Dublin Memoir*. Knopf, February 2018

Robert Bly (Minneapolis, Minnesota). *More Than True: The Wisdom of Fairy Tales*. Henry Holt and Co., March 2018

Richard Brilliant (Columbia University). *Death: From Dust to Destiny*. Reaktion Books, October 2017

Noam Chomsky (Massachusetts Institute of Technology) with David Barsamian (Alternative Radio). *Global Discontents: Conversations on the Rising Threats to Democracy*. Metropolitan Books, December 2017

J. M. Coetzee (University of Adelaide). *Late Essays: 2006 – 2017*. Viking, January 2018

Henri Cole (Claremont McKenna College). *Orphic Paris*. New York Review Books, April 2018

Antonio Damasio (University of Southern California). *The Strange Order of Things: Life, Feeling, and the Making of Cultures*. Pantheon, February 2018

Noah Feldman (Harvard Law School). *The Three Lives of James Madison: Genius, Partisan, President*. Random House, November 2017

Paula Fredriksen (Boston University). *Paul: The Pagans' Apostle*. Yale University Press, August 2017

Michael S. Gazzaniga (University of California, Santa Barbara). *The Consciousness Instinct: Unraveling the Mystery of How the Brain Makes the Mind*. Farrar, Straus and Giroux, April 2018

Linda Gordon (New York University). *The Second Coming of the KKK: The Ku Klux Klan of the 1920s and the American Political Tradition*. Liveright, October 2017

Patricia Hampl (University of Minnesota). *The Art of the Wasted Day*. Viking, April 2018

David M. Kreps (Stanford Graduate School of Business). *The Motivation Toolkit: How to Align Your Employees' Interests with Your Own*. Norton, January 2018

Alan Lightman (Massachusetts Institute of Technology). *Searching for Stars on an Island in Maine*. Pantheon, March 2018

Errol Morris (Fourth Floor Productions). *The Ashtray (Or the Man Who Denied Reality)*. University of Chicago Press, May 2018

Steven Pinker (Harvard University). *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress*. Viking, March 2018

Eric A. Posner (University of Chicago Law School). *Last Resort: The Financial Crisis and the Future of Bailouts*. University of Chicago Press, March 2018

Marilynne Robinson (University of Iowa). *What Are We Doing Here? Essays*. Farrar, Straus and Giroux, February 2018

Michael J. Sandel (Harvard University) and Paul J. D'Ambrosio (East China Normal University), eds. *Encountering China: Michael Sandel and Chinese Philosophy*. Harvard University Press, January 2018

Laurence Senelick (Tufts University). *Jacques Offenbach and the Making of Modern Culture*. Cambridge University Press, September 2017

Lorna Simpson (Brooklyn, New York). *Lorna Simpson Collages*. Chronicle Books, April 2018

Cass R. Sunstein (Harvard Law School), ed. *Can It Happen Here? Authoritarianism in America*. Dey Street Books, March 2018

Michael Walzer (Institute for Advanced Study). *A Foreign Policy for the Left*. Yale University Press, January 2018

Edward O. Wilson (Harvard University). *The Origins of Creativity*. Liveright, October 2017

Christian Wolff (Dartmouth College). *Occasional Pieces: Writings and Interviews, 1952 – 2013*. Oxford University Press, March 2017

Gordon S. Wood (Brown University). *Friends Divided: John Adams and Thomas Jefferson*. Penguin Press, October 2017

Richard W. Wrangham (Harvard University), **David R. Pilbeam** (Harvard University), and Martin N. Muller (University of New Mexico), eds. *Chimpanzees and Human Evolution*. Harvard University Press, November 2017

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

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