Induction 2007

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

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

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

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

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

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

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

Induction 2007

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

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

Peter Li '07 (University of California, Irvine)

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

Induction Ceremony

Challenges Facing a Global Society

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

Rodney Brooks

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Bonnie L. Bassler

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

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

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

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

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

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

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

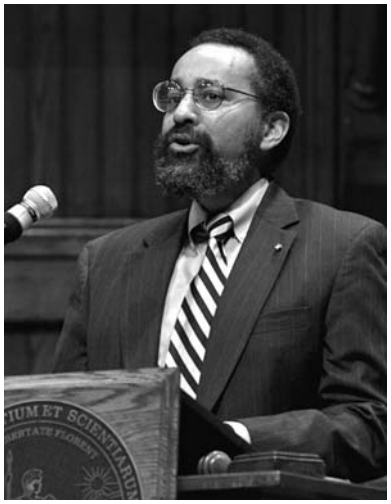
that we read about in the newspaper, and also all the miraculous things that are beneficial for us? Because they are so small, if bacteria only acted as individuals they could not possibly have an impact on their environment.

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

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

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

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



Christopher F. Edley, Jr.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Billie Tsien

Architect, Tod Williams Billie Tsien Architects, LLP

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

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

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

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

Knowledge is private.

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

Knowledge is private.

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

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

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

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

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

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

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

Robert J. Zimmer

President, University of Chicago

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

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

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

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

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

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

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

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

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

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

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

Jessye Norman

Opera and Concert Artist, New York, NY

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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