PURSUING THE ENDLESS FRONTIER: SCIENCE FOR FUTURE GENERATIONS

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BACKGROUND

This essay is based on remarks presented at a PKAL LI Leadership Seminar at the University of Maryland, Baltimore County, in October, 2005.

Thank you to Project Kaleidoscope for inviting me here. I am pleased to be here at the University of Maryland Baltimore County, and to follow President Hrabowski, who spoke to you yesterday. I am always glad to follow Freeman, because he makes me look like a very calm and relaxed individual. The accomplishments on this campus speak to his dedication, and as you learn about the progress at UMBC since he's been in the leadership at this campus, you will really understand that changes in a culture can happen. You will also see that it really needs leadership from both the top and bottom, all coming together around a vision. Freeman has made that happen here.

I am going to start with a quiz, and there is only one question: 'What was the size of a beach ball, weighed a little over 184 pounds, and changed the way the United States looked at math and science education forever?'

Exactly. It was Sputnik.

In the fall of 1957, the launch of Sputnik electrified and terrified the science and policy communities in much of our nation. Given the negative implications of that event, Sputnik was the spark that ignited the creativity and drive of our nation, and was the beginning of the "space race". In the two years following, we witnessed the founding of NASA, where years later I had the honor to be Chief Scientist. To ensure the security of the nation Congress enacted the National Defense Education Act of 1958, an act that connected our national security to the effort to require the fullest development of the mental resources and technical skills of our young men and women. Many leaders in today's scientific and technological communities attest that, "I started my scientific career based on Sputnik, with the support of scholarships made possible by the NDEA."

Given today's challenges, we must now ask "what is the Sputnik moment now, in 2005?" What are the stories that are shaping our future? Is it 9/11? Is it the energy challenge, the environment, is it globalization and a new way of doing business, is it the societal evolution to a knowledge-based society? Is it, as discussed recently by Dr. Robert Atkinson, president of the Progressive Policy Institute, our inability to have stability?

I suggest that it is all of these challenges, but more. I suggest that as we hear the alarm, we hear also the several voices saying that the combination of education and research may be the most powerful capability that our nation can nurture in times of stress and uncertainty. These are words from Leon Lederman in a New York Times editorial after 9/11. Indeed, the Hart-Rudman Commission even before 9/11 warned that our failure to invest in math and science education was the second biggest threat to our national security. This year [2005] the President's Council of Advisors on Science and Technology [PCAST] issued a report on sustaining the nation's innovation ecosystems. Its claims were based on the recognition that for the United States to continue to flourish within our global-based economy and knowledge-based society, we must have people with strong skills in fields related to technology, mathematics and the various fields of science and engineering.

So, what is the current challenge?

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In part, it is the same as in 1957. The PCAST report called for improving the K-12 teacher preparation, as well as undergraduate and graduate retention of majors in STEM fields. This is critical, because as you all know, we do not do a very good job of retaining the interest of students who enter our campuses with an interest to major in a STEM field. But our challenge is more than that. If you listen carefully, our leaders are really saying that if our country fails to invest in basic science and math, and fails to insist on quality education in scientific and technological fields, we will fall behind economically and in national security capabilities.

The actual [and proposed] increases to NSF by the Administration and from Congress are because our agency is seen as a symbol for the economic security of our nation and for a literate society in scientific, quantitative and technological areas.

But our current challenge is greater. We need to be one step faster than our colleagues and trading partners. Collectively India, China, Indonesia and Japan have more than doubled the number of students receiving natural sciences bachelor's degrees since 1975, and the European Union now produces more Ph.D.'s than the United States. These countries are eager to succeed in the 21st century and are increasingly capable of doing so.

We are in a race for ideas, a race for innovation, and it is really important that we recognize this as we shape our nation's educational and training programs in STEM fields, knowing that we live in a global world.

Organizations like PKAL and institutions like NSF use a bottom-up approach to provide a sturdy and successful foundation for research and education in STEM fields. We seek

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innovative answers to the complex problems our nation now faces. The best solutions we find are making their way into practice, sometimes replacing the older modalities. PKAL and NSF have enjoyed a long and productive partnership.

Central to our common purpose is a common approach that seeks answers to current pressing questions that can be validated by research and results. Our common focus is on the frontiers of research and education, and we both recognize (to quote from the PKAL web site), that the single greatest influence that transforms a student into a young scientist is an undergraduate research experience. I actually can attest to that, and will come back to this later.

Our vision of the ideal undergraduate faculty member is one whose research is coupled with teaching. At NSF, central to our strategic plan— really our mantra— is the integration of research and education. We know you cannot separate the two. All research proposals funded by NSF must satisfy two criteria: the excellence of the proposed research and of the impact on the broader community.

Given that we are here at the University of Maryland Baltimore County, I should point out that UMBC is an exemplary example of how to attract and sustain student interest, how to become a major producer of science and engineering majors, and how to change an institutional culture to become research-rich. Much of this happened, I am pleased to say, because of their partnership with NASA which gives UMBC students rich opportunities to do research as undergraduates.

But, since I grew up in Portland, let me also talk about Reed College, which has the Aprocess of discovery," a hands-on learning experience as the center of their academic program. Reed's productivity of Ph.D.'s, of Rhodes Scholars, and science majors was recognized by NSF when it named Reed as one of the recipients of the National Award for the Integration of Research and Education several years ago.

Reed is not unique. I went to Chatham College, just minutes away from the culture of the large metropolitan environment of Pittsburgh. I had to do a senior thesis to graduate (as required by Reed and many of the other institutions represented here). I had to design and carry out my own experiments, write up and defend the results of my research, and without that experience, I would not have been hooked on science.

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In fact, to interject a personal note, I went to Chatham "knowing" I was not going to major in science or math, based on my high school experience. But General Biology was the only thing I could fit into my schedule, and the teacher was great. The labs were fantastic, and I fell in love with biology. I was taking General Psychology at the same time, and it was based on the science. For me, it was like Nancy Drew. It was a mystery novel; it was dealing science in terms of story problems.

I was actually drawn into science arena, instead of being lost. NSF has programs that support the development of learning experiences such as I had at Chatham, and I know as well as anyone that these should be funded at a higher rate.

I am convinced that faculty/student interaction such as I had in college is a key ingredient to success, including mentoring programs that give students opportunity to work closely with faculty. You know also, I am sure, that NSF recognizes the value of mentoring for beginning scientists and for encouraging the participation of under-represented groups in STEM. In addition to mentoring, the Research Experiences for Undergraduates (REU) programs are a most important foundation-wide effort to expand student participation in STEM, and to integrate research and learning.

We can see common themes emerging in the work of PKAL and the NSF relating to the value of research in the undergraduate setting as a means to open up students' minds to the incredible opportunities for a diverse array of careers: do research in STEM education, in pharmaceuticals, biotech; become a zoo veterinarian, a venture capitalist; get engaged with technology transfer, law policy, television. We need to point out to our students that unemployment for scientists, even at the bachelor's level, is less than 4%.

I've even begun telling people that a Ph.D. in science should be like a law degree, opening up a wide range of careers. Vern Ehlers, a Ph.D. physicist, is now in Congress; Colin Powell was a geology major, although he says he recognized it would be better for the field if he went in another direction.

The science-fiction writer Isaac Asimov once said, "There is a single light of science, and to brighten it anywhere is to brighten it everywhere." We must be willing to lead the way in replacing the shadows of our world with a new light. To do this, we must be courageous and compassionate teachers, researchers, and policy-makers.

The opportunities for leadership exist at all levels. I might even press that statement further to say that it is a responsibility for leadership to exist at all levels.

I urge you within PKAL, and all others with a stake in our nation's STEM community, to take a leadership role in diversifying and strengthening the ranks of professionals in scientific and technological fields. We know everyone needs an existence proof, and what is being accomplished here at UMBC is such a proof.

When we call on students from under-represented populations to consider becoming a scientist or engineer, they need to see the role models leading the learning, the research, the societies and communities in STEM fields. Thinking about building research-rich learning environments which is what this seminar is about— is really critical for all of us.

Our way of doing things at NSF, as with PKAL, is to keep our ear to the group in search of best practices. We are looking for your good ideas to take back, to discuss, and to think about how NSF can perhaps tweak our programs to address your issues. You will be going back to your campuses to try and change your culture and your leadership, and I will be going back to NSF with that same perspective.

We have a common mission, to be involved in the continuing effort to pursue the endless frontier. This PKAL leadership initiative is a particularly fruitful way to keep discovering, enhancing, and renewing our nation's educational infrastructure.

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When I look at the horizon, what is exciting is not what we see; it is what we do not see. It's what is going on out there that we don't know— that the scientists and engineers of tomorrow will come to know— that will enable us to realize our dreams, to reach more creatively into the endless frontier.

The poet William Butler Yeats said, "education is not the filling of the pail, but the lighting of the fire." Thanks to you and others for lighting the fire. You are constantly changing, constantly evolving the learning environment into one urgently needed by our 21st century society.

Although I have been emphasizing workforce issues, it is also imperative that in our knowledge-based world, all citizens must have an understanding and knowledge of the sciences to make hard policy decisions about the power and potential of science and technology in our world.

May I close with some words about your work, and the work of Project Kaleidoscope. PKAL is now in its 18th year, and I want to thank you for your efforts in building and sustaining strong undergraduate programs in the fields of science, technology, engineering, and mathematics. I really cannot overstate the importance of your efforts for both generating the next leaders for science and engineering and in educating a scientifically-literate citizenry. I cannot emphasize enough that you and your work is critical for America.

For many years, Project Kaleidoscope has led the way in finding what works and putting those novel approaches into the college science classroom. Your community has continually experimented with new ideas and new frameworks, and thus has played a major role in continually reshaping and reforming undergraduate education. You have had a long history of success. At NSF and across the federal government, we support your ideas and actions, as well as your proof of a maxim that, and I quote, "what we stand for should never change, but how we do things should always be changeable." It is clear we share the same mission. NSF relies upon persisting help, like yours, in keeping the "endless frontiers" unfolding for coming generations of students. ■