“Making the Case for University Research”

Association of American Universities

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I appreciate this opportunity to speak with you in your roles as leaders of academia about a topic in which we have a mutual interest and which I believe to be of the utmost importance. But as I look around the room, I am reminded of an incident that took place on my first day as a member of the Princeton faculty following my retirement from earlier careers in business and government. I had been invited to present the welcoming lecture to the incoming freshmen engineers and as the Dean was introducing me I was busily reviewing my notes, not paying any particular attention to what he was saying. Suddenly, I heard him remark “. . . and now we will hear from Professor Augustine”. Truly, for just an instant, the thought went through my mind, “Gee, what a coincidence . . . they’ve got some guy here by the same name as me!”

I must confess to having that feeling today, being somewhat in awe of the responsibilities that each of you bears. Several years ago I wrote an article comparing the challenges of management in government, industry, academia and charitable institutions and came to the conclusion that, far and away, the most difficult is the position that you hold. I am also concerned today that I may be somewhat guilty of bearing coals to Newcastle.

The role of research universities in underpinning our nation’s standard of living is of pivotal importance, both as a source of talent and as a source of fundamental knowledge. And speaking as a resident of our nation’s capital—which admittedly has, on occasion, been described as a “diamond-shaped city surrounded on all four sides by reality”—I have concluded that this contribution of academia is under-appreciated by many who bear responsibility for funding the very research of which I speak. Too often it is taken for granted that our universities will more or less automatically continue to generate the breakthroughs that have fueled our economy for many years. It was in this general vein that my friend, Dan Goldin, told me when he was Administrator of NASA that he had received a complaint from a disgruntled citizen who inquired, “Why do we need meteorological satellites . . . we have the weather channel?”

It was my privilege during the late 1990’s, well-prior to 9/11, to serve as a member of the Hart-Rudman Commission on National Security. Our final report stated, in part, that “. . . the U.S. government seriously under-funded basic science research in recent years . . . the inadequacy of our system of research and education poses a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine. America’s national leadership must understand these deficiencies as threats to national security. If we do not invest heavily and wisely
in rebuilding these two core strengths, America will be incapable of maintaining its
global position long into the Twentieth century.”

Mind you, that was one of the two principal findings of a panel that was
established to investigate national security—not education. I should probably add that
the other primary finding stated that “The combination of unconventional weapons
proliferation with the persistence of international terrorism will end the relative
invulnerability of the U.S. homeland to catastrophic attack.” We went on to say that a
major direct attack against American citizens on American soil with heretofore
unimagined casualties was likely, and that a National Homeland Security Agency should
be established with Cabinet status to address that threat. As we now know, our prediction
proved to be all too accurate. Unfortunately, the tragedy of 9/11 occurred before any of
our Commission’s principal recommendations were implemented. Fortunately, however,
it is not too late to address the other concern that we raised, namely, the health of our
basic scientific research enterprise which is principally harbored in the nation’s
universities. But the clock is ticking.

Now, you may be wondering what would prompt an individual who is primarily a
product of the business/industrial world, as indeed I am, to have become so involved in
seeking to strengthen the research base of universities. While it is probably true that
some of my CEO friends viewed me as a bit of a closet academic, my motives were not
entirely eleemosynary. In fact, they were, and are, quite pragmatic. You see, I was
responsible for a firm whose future existence was dependent, heavily dependent, upon the
competitive margin that could be generated by the 62,000 engineers and scientists with
whom I worked.

I was well aware of the studies that had shown that over fifty percent of the jobs
created in America during the last half century could be directly attributed to investments
in science and technology. I was acutely aware that most of our own company’s sales
were derived from products that did not even exist a few years earlier, and that much of
our backlog was attributable to products that did not exist yet. In the case of another
firm, Intel, I had been told that nearly ninety percent of all the products they sell in any
given year did not exist a year earlier. Even a consumer products firm such as Procter
and Gamble, on who’s board I have served for 17 years and is generally construed to be a
marketing powerhouse, is, as its management would freely tell you, fundamentally an
R&D enterprise.

I was also deeply troubled that most of the corporate boards on which I serve
were increasingly being called upon to approve proposals to relocate factories outside the
United States—and I must confess that, given the plausible alternatives, I was among
those who generally voted in favor of doing so. It was almost certainly in the best
interest of our shareholders, and, ultimately, of our remaining employees, to conduct
more and more of our manufacturing operations in such places as Asia, India and
Mexico. I recently visited a factory in Vietnam where the wrap-rate was about twenty-
five cents per hour . . . far less than most American firms pay simply for medical
insurance for their employees. Furthermore, litigation expenses, almost non-existent in
much of the rest of the world, have grown to represent a cost to American firms which exceeds their overall investment in research and development.

But the trend to relocate abroad did not stop with factories and factory workers. I soon learned that we could hire eleven engineers in India for the cost of one in the United States—as many of the competitors we daily confronted in the marketplace were in fact doing. We could hire even more in Russia—and these too were highly-qualified engineers, many educated in the United States in your institutions. But even that was only the beginning. Soon we were being asked to approve moving our design teams and software production abroad. More recently, our research laboratories have joined the exodus.

You are familiar with the statistics. China graduates about 200,000 engineers a year; India and Japan 100,000; the United States 50,000. In the United States, five percent of the bachelor’s degrees awarded are in engineering; in China, the corresponding figure is 40 percent. In Singapore, the fraction is even higher.

In 1999, as America’s youth continued to turn to other fields of study, the number of foreign students pursuing graduate studies in math, the physical sciences and engineering in U.S. universities surpassed, for the first time, the number of American students. But unlike years past, an increasing number of these students are now returning home upon completing their degrees. Further, the number of foreign students applying to U.S. universities has begun to decline, in part due to recent contention over the granting of visas. Taken together, these factors have made it increasingly difficult for our economy to continue to be supported to a material degree by the contributions of highly capable foreign-born scientists and engineers—individuals who were often attracted to America’s universities by of the vibrancy of the research conducted there and the opportunity to study in an environment embracing freedom of inquiry. One result of this surge of immigrants was that at the beginning of the twenty-first century, 57 percent of all postdoctoral positions in the U.S. were filled by foreign-born scholars.

Today, America’s companies find themselves in a marketplace without borders—or, at the very least, with borders that are extremely permeable. And it is quite clear that we are unable to compete in this global marketplace on the basis of favorable domestic labor costs, at least not in a manner that would be tolerable to our citizenry. Only one acceptable choice remains, and that is to be among the world’s foremost innovators . . . and the underpinning of innovation is research, particularly research in science and technology, and this, as you know, is increasingly becoming the relatively exclusive province of our nation’s universities. This is where the breakthroughs, the “Big Bangs”, that have profound impacts, are produced. And this is an endeavor that is highly vulnerable to neglect because the consequences of neglect, although severe, are often not suffered for a number of years. Further, the trend is not easily reversed—as some great scholar once noted, you can’t produce pigs by running the sausage machine backwards.

One might reasonably ask why, if in the last dozen years, inflation-adjusted research and development conducted in America has increased by two-thirds, one should
be alarmed about the health of the nation’s research enterprise. Furthermore, the industrial sector seems to have been picking up whatever slack in R&D growth might have been caused as the federal government sought to deal with its growing non-discretionary funding burden. In fact, industry R&D spending surpassed government spending in 1980, and now comprises more than double the amount of funds that the government appropriates.

The answers are fairly straightforward. First, almost all the increase in government research spending has been devoted to the biosciences—an extremely important investment and one that is to be applauded. Unfortunately, while pursuing this laudable course, investment in the physical sciences, mathematics and engineering has been badly neglected. In the physical sciences, federal research spending has been roughly flat as measured in constant-purchasing power, while funding in mathematics and engineering has only slightly surpassed inflation. Correspondingly, the number of Bachelors degrees awarded by U.S. universities in these fields since 1985 has dropped by 11, 28 and 21 percent, respectively. Just as graduate students tend to be keenly aware of where the most exciting research is to be found, undergraduate students seem to be keenly aware of where the jobs are to be found.

Turning to industry, while overall industry-funded R&D has in fact increased markedly, these monies have largely been devoted to development activities as opposed to research—and those funds which have in fact been devoted to research are increasingly focused upon applied research rather than basic research of the type generally performed in universities. Current indicators of this trend include the diminished status of such renowned institutions as Bell Labs or, closer to where I live, the closing several years ago of Martin Marietta’s corporate research laboratory. The former produced such transformational innovations as the transistor and the predecessor to the laser; the latter employed the creator of the Kalman filter.

Why should this shift in priority towards near-term payoffs be occurring? To answer this question let me share with you a vignette that illustrates the dilemma faced by corporate executives in prioritizing research initiatives. Several years ago, the company I then served, Martin Marietta, one of Lockheed Martin’s predecessor firms, concluded that it had an unusually rich set of opportunities that could be reaped by increased investment in applied research. So enthused were we about these prospects that we called a special meeting in New York of Wall Street analysts so our president could describe our exciting plans in considerable detail. But upon completion of his presentation, the audience literally ran from the room . . . and sold our stock.

The price of our stock plummeted the next day and continued to decline gradually for another eighteen months as we persisted in our strategy—bravely ignoring the admonition about stopping digging when you have reached the bottom of a hole. I particularly recall the remarks of one analyst who, when asked what we had done wrong, replied, “Everyone knows it takes ten or fifteen years for investments in research to pay off—but your shareholders, on average, only own your stock for a little over a year before they sell it. The benefits of your research, if there are any, may be of interest to
the great-grandchildren of your shareholders—but today’s shareholders shouldn’t be asked to foot the bill for it. Our fund doesn’t invest in companies with such short-sighted (emphasis added) management”.

That is what he said. Very sobering to a CEO in today’s world wherein, on average, a CEO can expect to be around for only about five years and, even without such provocative actions, already has one chance in three of being fired before having finished his or her planned term. The obvious conclusion is that investing in long-term research is conducted at one’s peril. The market likes results in the next quarter.

A further complication stems from the fact that it is often not evident which fields of endeavor might be impacted by a particular investment in research, especially basic research. From an industry investment perspective, a very “successful” research project might produce results that would only benefit other firms, perhaps even the sponsor’s competition. I am reminded of an instance many years ago when an employee of Martin Marietta, asked management to underwrite a project to adapt some advanced materials which were being pursued in one of our laboratories to the construction of composite skis and tennis racquets. The management, undoubtedly correctly, declined—noting that the company was in the aerospace business, not the sporting goods business. Having been given authority to pursue the idea on his own, the employee founded the firm that today bears his name: “Head”!

But if industry is to abdicate its responsibility to feed the front-end of the innovation machine, even for arguably justifiable reasons, who then is to do so? A case can be made that the support of generic, broadly-applicable, high-payoff and often risky research is an appropriate province of our government. This has in fact been widely and beneficially recognized for many years and has resulted in the creation of such agencies as the NSF, NIH and DARPA and the DOE science program. The notion that government should underwrite broadly applicable research for the overall benefit of its citizenry, especially when that research is unlikely to be otherwise performed, seems supportable . . . just as our government provides highways and national security forces for the common good.

The problem resides in the inadequacy of resources being made available for research in the so-called “hard sciences”. As has been noted, federal funding of the physical sciences, in constant dollars, has been flat for a third of a century, and funding of mathematics and engineering nearly so, even as the size of the overall economy which must be supported by such effort has grown markedly. This has taken place as we have become increasingly dependent on science and technology for jobs, healthcare, energy and national security. In effect, we have created a huge “inverted pyramid” of jobs, corporations and technology which to a large extent is supported, rather precariously, at its fulcrum by a program of university research.

The bottom line is that in the last two decades, the U.S. share of global exports has fallen from 30 to 17 percent, while those of Asia, excluding Japan, grew from 7 to 27 percent. For the first time in memory, the U.S. now has a negative trade balance for
high-technology products—and the jobs associated therewith are fast becoming one of our major exports. It should probably be noted that this cannot be viewed as a partisan issue: the problem did not occur overnight. Unfortunately, it will not be rectified overnight, either.

These, then, were some of the considerations that caused me, with strong encouragement and support from such individuals as Burt Richter, Chuck Vest and the current president of your Association, Nils Hasselmo, to undertake a campaign which would call increased attention to our nation’s under-investment in university research. To my surprise, in doing so I was afforded considerable credibility by many of the decision-makers with whom I spoke—more credibility, I might add, than I ever enjoyed when I spoke on behalf of another cause which I deem to be important: the health of our nation’s armed services. In retrospect, the reason is obvious: It was viewed that I did not have a personal stake in the outcome of funding decisions affecting our nation’s research universities. That, of course, is incorrect, since every citizen has an enormous stake in that outcome, however, the connection was somehow deemed to be indirect. This is, of course, part of the problem.

My initial efforts on behalf of university research began a decade or so ago and consisted of writing an op/ed piece encouraging greater federal investment in our research universities. The CEO’s of sixteen of the nation’s technology-dependent corporations joined me and placed their handwritten signature on the piece. These sixteen corporations employed a non-trivial share of the nation’s workforce and included such companies as IBM, Motorola, Eli Lilly, General Electric, Dupont and McDonnell Douglas. But to my chagrin, no major newspaper considered our op/ed worthy of the ink to print it! Personally, I thought it would have been quite remarkable to get sixteen CEO’s to agree to place their signature on a piece of paper that bore nothing but the date—let alone encouraging spending that did not accrue directly to their shareholders!

Whatever the case, we swallowed our pride and ran the article in paid, full-page advertisements in the very newspapers that had rejected us. Through a fortuitous confluence of timing and personnel happenstances, some members of Congress seemed to be more impressed with our message than had been the media, with the result that we may have had a modest impact on increasing research funding in a few areas and cushioning planned reductions in others. You might find it amusing that later that year the media’s professional association awarded our aborted op/ed piece a very impressive trophy as the “Advertorial of the Year”!

It is my belief that were industry and our universities to work more closely together in explaining the importance of fundamental research, a much broader acceptance of the notion might be realized. Similarly, it would seem to me that an increase in industry funding of research performed at our universities would benefit both parties. I am, of course, aware of what engineers might refer to as impedance mismatches attendant to such undertakings. In industry, the rhythm, or “time-constant”, tends to be the fiscal year . . . if not the next quarter. In academia, the corresponding time-constant is six or seven years—the period required to earn a doctorate. In the
university community, an oft quoted motto is “publish or perish”. In industry, the corresponding motto might well be “publish and perish”! Further, legitimate concerns have been raised about the hazards of industry, if it is to become a significant source of funds, seeking to exercise inappropriate influence over our universities. Nonetheless, I believe these obstacles can be surmounted—particularly as industry realizes the economic leverage associated with grad students as part of the labor force! I can still recall that when, as a senior, I was “promoted” from my job as a waiter at Howard Johnson’s to an assistant in the research laboratory, my wages *dropped* by a fact of four!

What then are some of the lessons that have been learned from a decade of visiting about this topic with editorial boards, numerous members of Congress, the head of OMB, the Vice President and, informally, two Presidents? What was perhaps the introductory lesson in my campaign was brought home rather forcefully during a session a number of years ago with a newly elected member of congress from New Jersey, an individual whom I had not previously met. Hoping to build some modest sense of rapport, I began the visit by noting that I had lived in New Jersey when I attended Princeton. His response, delivered without a trace of a smile, was, “Princeton isn’t part of New Jersey”!

At this point I would request you permit me to assume the role of a reporter, neither defending nor criticizing the perspectives that I will share.

First, it became abundantly evident in my role as a relatively neutral party that, although I found America’s academe broadly and highly respected for its scholarly excellence and its much deserved position in the world’s educational hierarchy, its researchers were often resented by the very officials who have a say in the allocation of federal research funds. Some of this sentiment is probably inevitable: most of us are reluctantly forced to recognize that those who perform such work are probably considerably smarter than we. It also does not go un-noticed in the halls of government that many of these individuals, unlike most citizens, enjoy what is referred to on Capitol Hill as guaranteed employment—considerations of freedom of expression notwithstanding. I also found a certain unspoken reluctance by some legislators to support institutions which they view as elitist; institutions whose tuition, even after scholarships, grows at a rate considerably exceeding the growth in income of the general populace—and which rejects the sons and daughters of the Washington cognoscenti at a rate which does not go unobserved. And, finally, I would gratuitously note that when scientists, as a group, take public positions on contentious subjects having at best marginal relationships to science, it rarely endears them to all members of the political establishment.

I further discovered that relationships within the nation’s research community itself in many instances make last year’s Los Angeles Lakers appear to be Miss Congeniality! On several occasions, after having made an impassioned plea for university research funding, I would learn that my footsteps had been followed by groups of scientists wherein the physicists argued that any new money should be spent on physics and certainly not on chemistry; but the physicists then argued among themselves whether new money should be spent on particle physics or astrophysics; the particle...
physicists, not to be daunted, argued that the new money should be spent investigating neutrinos not searching for the Higgs particle; and the neutrino physicists who were experimentalists asserted that new funds should certainly not be wasted on theoreticians!

The result of this cacophony was that many members of Congress, perhaps understandably, tended to throw up their hands: If the experts can’t agree on how money should be spent, and the members don’t have the time, or perhaps even inclination, to learn the difference between a boson and a lepton, it is best that the money simply be spent on highways. (Incidentally, I have sensed that there was more than a small amount of this type of thinking that contributed to the demise of the superconducting supercollider.)

It is undoubtedly a truism that there will always be more research to support than there can be support for research. One of the inspiring aspects of research is that every time a door is opened, it seems to lead to a room with three more doors. But this does imply that choices must be made and communicated, in at least broad terms, with legislators who, not unreasonably, like to know what it is in which they are investing. In discussing this with legislators I have found it helpful to conceptually separate research into three general categories.

The first of these includes research bearing a reasonably high probability of producing a significant, positive impact on the standard of living of Americans and, hopefully, the citizens of the world as a whole. In this category, one might include research on such topics as the human genome, optical computing or nuclear fusion. I would argue that America should seek to be the leader or at least among the world’s leaders, in such research. Jack Welch’s dictum for executives is that if you can’t be number one in your business, or at least number two, you had better get out of the business! I suspect that may be a bit uncompromising when it comes to research, but it does point to the undesirability of being an “also-ran” in fields critical to one’s future.

The second category includes research with outcomes of a less certain nature which, even if successful, would most likely produce somewhat marginal impacts on the quality of life. This is a particularly difficult category to evaluate since the very essence of research is that you don’t know what you don’t know. You will recall that it was Tom Watson, the much-admired Chairman of IBM, who in 1943 remarked “I think there is a world market for about five computers” . . . or that it was Bill Gates in 1981 who observed, “640K ought to be enough for anybody.”

I would nonetheless argue that investments in this category should be held to whatever minimum level is needed to “monitor” the field so that should an unexpected breakthrough actually occur, we would be in a position to at least recognize and participate in exploiting its results. One might include in this category, research aimed at generating new construction materials that might, say, replace steel or concrete.
Finally, there is a third category of research that appears to offer very limited prospects of practicable application, yet addresses some of the most profound and exciting issues one can imagine. Astrophysics, particle physics, even the search for extraterrestrial life, might be representative of this category. The problem is that in making assignments to this category one can be terribly wrong. For example, I doubt that the early researchers in the relatively esoteric field of quantum mechanics realized that they were laying the foundation from which the transistor and the modern electronics industry would spring.

It would thus be my proposal that America invest substantially in two or three of the most intellectually challenging pursuits in this category, perhaps in cooperation with researchers of other nations, and do so in part as a “civic responsibility”—and to seek to be among the leaders in the relevant fields. Unfortunately, even great nations can afford only a few such causes—but surely they should afford some.

What, then, can I recommend today that might prove helpful to you?

My first suggestion is that wherever possible, and it will not always be so, adopt pragmatic arguments when making the case for increasing the nation’s spending on academic research. By pragmatic arguments I mean those that relate such spending to the creation of jobs, the enhancement of health, the assurance of physical security, and so forth. I conclude this with a sense of sadness, because I am among those who believe that the search for knowledge has merit in its own right. If we cannot afford to study the origin of the dinosaur because it may not create jobs, not even for dinosaurs, does that also suggest that we should not take time to watch Shakespeare performed, listen to Beethoven’s works, or cheer Roger Clemens’ fastball? Whatever the case, I do know that it is difficult to obtain government support in today’s challenging funding climate for pursuits that do not produce a rather clear, direct impact on the quality of life of the average citizen.

On the other hand, when this connectivity is convincingly demonstrated, the nation’s policy makers appear to be willing, even eager, to invest. Witness the substantial increase in funds devoted to conquering diseases. The problem, as the saying goes, is that no one ever died of physics, chemistry, math or engineering—although, in my opinion, whoever said that never took freshman physics from the highly regarded Professor John Wheeler!

My second suggestion is that some degree of internal consensus be established within the academic community as to priorities for allocating resources. If this is too much to ask, and it may well be, at least a “truce” is needed whereby the various interested partisans make their cases without attacking those of others.

Third, in addition to the participation of leaders of the academic community, spokespersons need to be enlisted in the cause who are independent of our research universities and do not suffer the appearance of being self-serving. The irony is that most such individuals, certainly including myself, know little about university research—
but they are at least attributed some degree of understanding of the benefits of such research. This accounts—in my opinion—for the remarkable success groups of citizens concerned with various diseases have had in doubling the NIH budget in recent years.

Fourth, successes achieved from our government’s investment in research need to be broadly publicized and publicly attributed to government support. I have found that relatively few people are aware of the important role physics, chemistry, engineering and mathematics play in underpinning health research; for example, the contribution of robotics, computers and mathematics in deciphering the human genome, or the role of mathematics and engineering in modern non-intrusive imaging techniques. Even fewer citizens and elected representatives seem to be aware of studies such as the one that concluded that research conducted at MIT alone had in recent years generated over 4,000 companies and created over a million jobs.

Fifth, and finally, I recommend hard work—and an abundance of perseverance! In this instance, the most effective form of “hard work” is communicating the old fashioned way: face-to-face contacts with individual members of Congress, the administration and the media. Consider the possibility that everyone in this room might commit to see three such individuals for fifteen minutes, each and every time you are in the nation’s capital—not asking for anything for your own institution but rather speaking on behalf of generic investments in basic research. It is my belief that you would find yourselves very welcome and that you would have an enormous cumulative impact.

Some years ago, when I had just become Under Secretary of the Army and recognized that I had virtually no experience in Washington politics, I assigned myself the task of conducting five such meetings each week—in that case, on behalf of the Army. I reported very candidly on our problems as well as our opportunities, never overstaying my fifteen minutes and never asking for anything specific. The goodwill one builds is amazing; as is the arithmetic: Within three years I had seen virtually all of the 535 members of the House and Senate at least once. In this regard, it should be noted that it is also important to visit the members in their home district, where they have more time to devote to longer-term issues. Including respected local citizens in these visits amplifies the impact of the message being conveyed.

I would summarize by noting that the bad news is that our nation’s investment in research in the physical sciences and engineering is only about one-tenth of one percent of the nation’s GDP. But the good news is that the nation’s investment in research in the physical sciences, mathematics and engineering is only about one-tenth of one percent of the nation’s GDP! Major proportionate increases can therefore be achieved with relatively modest overall impact on the federal budget. For example, the federal research effort in engineering, math and the physical sciences could be doubled by increasing the gasoline tax by a dime per gallon. An amount almost lost in the recent increases. For perspective, the entire research budget in all these fields is less than the amount by which healthcare costs in America increase every two months. There is enormous leverage available for research to recover increased investment.
Let me thank you for your forbearance in permitting me to address this admittedly contentious topic with more candor than is perhaps customary or appropriate before such a distinguished audience.

I would like to close with a poem attributed to Richard Hodgetts that I often shared with my colleagues at Lockheed Martin as we contemplated the intense competitiveness of the global marketplace. It goes as follows:

_Every morning in Africa a gazelle wakes up.  
It knows it must outrun the fastest lion or it will be killed._

_Every morning in Africa a lion wakes up.  
It knows it must outrun the slowest gazelle or it will starve._

_It doesn’t matter whether you’re a lion or a gazelle – when the sun comes up, you’d better be running._

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Norman R. Augustine is the retired Chairman and CEO of the Lockheed Martin Corporation and former Under Secretary of the Army. He has been a trustee of MIT and Princeton and is currently a trustee of Johns Hopkins. He was a founder of the Maryland Business Roundtable for Education and chaired the (National) Business Roundtable’s Education Initiative and has been Chairman of the National Academy of Engineering. He has served as a Lecturer with the Rank of Professor at Princeton University and is a recipient of the National Medal of Technology and holds a number of honorary degrees.