It's really an honor to be here at the University of California, Davis to present today's Chancellor's Colloquium.

I've been proud to have Dr. Linda Katehi as a colleague and a friend since I first knew her as an assistant professor at the University of Michigan. Let me assure all of you that throughout this nation, she is an admired educational leader.

The Massachusetts Institute of Technology (MIT) that I served for 17 years was established 150 years ago. It was founded to be a new and different kind of institution to serve the purposes of the emerging industrial age in the United States. Today, in the dawning decades of the 21st Century, institutions are needed to serve the purposes of the emerging global, knowledge-based economy and interconnected world.
Around the world, many universities, based largely on the model of the American Research University, are being established with this purpose in mind. Prime examples are the King Abdullah University of Science and Technology (KAUST) in Saudi Arabia, the Okinawa Institute of Science and Technology in Japan (OIST), the Singapore University of Technology and Design (SUTD), and the Skolkovo Institute of Science and Technology in Russia (SIST).

Interestingly, much of the leadership as well as the design of these and several other new universities are being provided by educational innovators from the U.S. who see these institutions as opportunities for educational change. In the U.S., some important new universities such as Olin College in the Boston area have also been established in this context.

“Times may call for transformation rather than evolution, but in any event, change must come.”

For the most part, because our research universities have been very energetic, successful and somewhat intellectually flexible, our U.S. strategy is most likely going to be based on the evolution of existing universities. Times may call for transformation rather than evolution, but in any event, change must come. Change is called for from two major directions. First, globalization and the future ability of the United States to compete innovate and lead; second, the need to keep our universities both excellent and accessible.

One highly relevant characteristic of globalization is the movement of people, ideas and information. In the mid-20th century, we all spoke about brain drain. The implication was that many of the brightest and most energetic young men and women from all over the world emigrated to the U.S. or to Western Europe where they found the most adventurous and well funded universities in which to study or become faculty members, especially in recent years in science and engineering. These immigrants also became entrepreneurs and corporate leaders in their new country, but these talented individuals were drained from their home countries where some would argue that they were needed even more.

As we moved into the 21st century, we entered the current era of brain circulation. This means that bright young people now move around the globe, studying and doing business in many different countries that present opportunities to them. Our research universities and their students will serve the needs and meet the opportunities of our states and nation, but they will also be global citizens. This is very different from the more insular national context in which MIT was founded 150 years ago.

But I think that today we are at the beginning of an even more exciting phenomenon that I call “brain integration.” By this I mean that researchers, students and entrepreneurs all over the world are linked together by the internet World Wide Web and they soon will all have access to massive computing power through the so called “cloud.” Increasingly, communities of scholars, scientists, engineers and others in many different locations around the world will integrate their thinking with the data and analyses of large-scale computation to solve big problems. I believe that this brain integration will characterize the age in which our
universities will leverage and expand their abilities to make major scientific and technical contributions to humankind.

Brain integration will also contribute to the learning process in ways that frankly I can only see at this time through a glass darkly. Indeed things are stirring on the brain integration front. A highly interdisciplinary group at MIT has established the center for collective intelligence dedicated to answering your core research question: how can people and computers be connected so that collectively they can act more intelligently than any person, group or computer has ever done before?

A group of researchers at the University of Washington developed a computer game called Foldit to solve puzzles for science. This website attracts players from all over the world to collectively solve

“If we can integrate people’s computers to solve very complicated problems, why can’t we actually integrate their brains?”
protein folding problems. Foldit’s origins are telling. Researchers have often obtained the massive computer power they need to solve problems like this by chaining together a large number of PCs that are volunteered by their owners all over the world. One day, at least so to speak, the researchers thought; if we can integrate people’s computers to solve very complicated problems, why can’t we actually integrate their brains? That is, use their human intelligence and intuition collectively to solve such problems. Foldit has proven to be effective and it is also set up in a way that the gamers can learn about the actual science that they are involved with.

Finally, I would note the interesting explorations of the gaming and learning world and recent book by Douglas Thomas and John Seely Brown, A New Culture of Learning. They conclude that a new culture of learning is emerging from the world of massive, multi-player games that are “a culture of collective inquiry that harnesses the resources of the network and transforms them into nutrients within the petri dish environment turning it into a space of play and experimentation and where imaginations play, learning happens.”

Do the concepts of brain circulation and brain integration imply that locations of universities no longer matter? Absolutely not. Where universities are located certainly still matters. University campuses, in my view, will not become obsolete just because the world is interconnected by information technology.

I think this is true for at least three reasons. First, teaching and learning are profoundly human activities. Machines can and will enhance these processes, and they will make vast amounts of information available, but I think that the magic that happens when students and scholars live and learn together will not be replaced. It will be greatly enhanced by information technology, but not replaced.

The second reason that location still matters is that each university develops its own specific infrastructure for experimentation and analysis. One of the great promises of what I’ve called “brain integration” is that expensive equipment will not have to be duplicated on all different campuses, but rather they can be shared in global collaborations.

The third reason that location still matters is that universities exist in cultures. Despite the many forces that drive us towards sameness across the U.S., different universities both public and private do develop their own cultures, and may it always be so.

Let me step back for a moment and give you my view of what the purpose of research universities is. We generally and properly think of ourselves as stewarding the ancient purposes of preserving knowledge of the past, teaching and producing new knowledge and
Few people actually understand that research universities are truly central to innovation.

But U.S. research universities also provide opportunity for business and industry. They do this by providing well educated and well trained employees, but even more profoundly, through their research they provide ideas for new products, processes and services.

Here again location does matter because face-to-face interactions of faculty, students, entrepreneurs and business leaders can generate a synergy that is critically important in doing new things that can be successful.

My friend and colleague Desh Deshpande, a very successful Indian-American entrepreneur has taught me that successful entrepreneurs are men and women who understand the real needs of real people and who have an appreciation for what will or will not work in a given culture and location.

Finally, the flow of people and ideas to and from research universities provides opportunities for states, regions and nations. This is the opportunity to enhance economies, health, security and quality of life. But here I want to add one caution: patience and flexibility are required. It is very difficult to plan and predict exactly how and when a research university will advance the economy of a region.

No one planned route 128 around Boston and no one even planned Silicon Valley. They emerged, in large part, because universities like MIT and Stanford brought smart, innovative and adventurous faculty and students together who developed strong interaction with local business people and companies.

MIT and Stanford also share a critically important characteristic. In both of these institutions, the most fundamental research and scholarship exists side-by-side and in mutual respect with highly applied and even industry-relevant research.

As academics, we generally think primarily of the flow of new ideas and technologies from our universities to companies, but in fact, we are one element of a very complex national innovation system. This is not a well-defined system. It’s a complex flow of people, ideas, and money. It involves governments, universities and industry.

Though innovation has become part of the vernacular, possibly too much of the vernacular, I find, to my dismay, that few people actually understand that research universities are truly central to innovation. Indeed, they are arguably the most important part of this system. Innovations originating in universities have created truly transforming opportunity to our nation and our world. Consider, for example, the following university-developed innovations: computing, the laser, the internet, numerically-controlled machines, the
fundamentals of the GPS system, the gnomic revolution, the deployment of the World Wide Web and most of modern medicine. There’s not a job in America today that does not depend on one or more of these university-derived innovations. This is very serious business.

Furthermore, studies show that there are other reasons that universities attract start-ups and other forward-looking businesses to their vicinity because universities help to provide an attractive intellectual and cultural environment and improve the quality of life for companies and their employees. They also tend to stimulate improvement in educational quality at all levels in their communities. In addition, they provide a stimulating and neutral venue where scientists, engineers, scholars and business leaders can openly discuss topics of mutual interest.

Research shows that these factors are very important to companies when they decide to locate their businesses or laboratories. The mission to provide opportunity for our graduates is obviously broadly accepted. The missions of providing opportunities to states, regions and especially businesses creates some tension within our universities, but in my view, these tensions must be positioned to be so-called “creative tensions” because I do believe that with our great public universities, this purpose is both important and, when properly executed, noble.

Before addressing change and how to proceed in the changing context of globalization and financial stress, we should recognize that our U.S. research universities have been remarkably successful. We must not lose sight of how successful we have been, but neither can we rest on our laurels.

I suggest six basic lessons from the experience of research universities in the 20th century. The first lesson is that teaching and research must be intimately intertwined and must be assigned equal importance. Teaching, research and scholarship are inseparable, and it is their synergy that defines the essence of a research university.

Many years ago, Frederick Terman, then the Provost of Stanford, was asked whether he wanted Stanford to be a teaching institutions or a research institution. He answered that he wanted it to be a learning institution.

The research university of the 21st century must also be devoted to learning in this broad sense; learning through discovering as well as learning through teaching and exploration of the past. In the long run, making universities exciting, creative, adventurous, rigorous, demanding, and empowering environments is far more important than the specific details of individual curricula or research programs.

The second lesson is that the quality of a research university can be no better than the quality of its faculty. The faculty defines the university. The research university of the 21st century therefore must drive to attract, nurture and empower the very best professors. This essential task of building a world-class faculty requires commitment, fortitude, patience and adherence to high academic values as well as to aspirations. Some well-experienced, excellent senior professors need to be hired from time to time, but in the end, I believe that it’s very important that young faculty grow up through the ranks of a university.

Science can flourish only in an open environment.
Lesson three is that science can flourish only in an open environment. Science languishes in a closed environment. The free flow of people and ideas across institutional and political boundaries is essential to the functioning of a great university. The very process of conducting science requires that others challenge one’s hypotheses, independently verify the results of the experiments and validate theoretical conclusions. Science simply cannot even be done in isolation. And of course interactions among scholars, scientists and engineers who have diverse perspectives and varied experiences leads to creativity and innovation. Such interchange is the very essence of a research university. Maintaining an intellectually open environment requires a high degree of institutional autonomy and protection from political and ideological forces.

Lesson four is that it is essential to give great freedom to new, young faculty members to study and teach what they believe is important. They should not function as assistance to senior faculty. The wisdom and perspective of senior scholars are obviously important, but most dramatic new insights and innovations come from brilliant young women and men, but with great intellectual freedom comes equally great responsibility. Thus faculty, even in their early careers, must always be held to the highest academic standards, especially through the evaluation and constructive criticism inherent in peer review processes. The freshness that comes from young faculty and from the continual flow of students to the institution is key to a great research university.

“Washington is broken. I hope and expect that this is a temporary state, but it is broken in the sense that we are avoiding addressing the truly important issues of our time.”

Lesson five is that competition among universities to attract and retain the best faculty, students, and competition among professors and research groups in the free marketplace of ideas engenders excellence. Such inter-institutional competition may at first seem expensive, inefficient and complicated especially because today’s universities compete on a global scale. Nonetheless, I believe that competition drives improvement in research, teaching, educational policies, working environments, facilities and most importantly in ideas and people. Great professors attract great students, and great students attract great professors.

Lessons six is that fundamental scholarship and research must exist on an equal plane with applied research and innovation. I emphasized this earlier in my talk. As we enter the 21st century, we are very aware that research universities create opportunities for nations and region through the transfer of technology and innovation to the marketplace.

Industrially relevant work is increasingly important and an environment that is entrepreneurial also gives relevance to education. However, there is a danger that in our rush to solve practical problems and transfer technology to industry, we could lose our bearings and forget the still more profound purposes of universities; to discover truths about nature, celebrate ideas and advance the human spirit. We must not allow universities to become overly utilitarian, but universities are places where ideas must be exchanged, evaluated, and integrated.
Even in an institution like MIT that is largely centered on science and engineering, truly fundamental research and scholarship conducted to discover truths about nature and the human condition play a central role equal to that of research that is applied quite directly and to the solution of major problems facing humankind.

Both pure scholarship and applied research must be conducted with mutual respect, both must be valued, both must be subjected to the same rigorous standards, and (this is important) they should inform each other.

Now I’m an incurable optimist, but I have to say that never in my lifetime has it been so hard to hang onto my optimism as it is today. I find myself slipping daily into one degree or another into pessimism. Washington is broken. I hope and expect that this is a temporary state, but it is broken in the sense that we are avoiding addressing the truly important issues of our time. Instead, our politics is focused on sideshows, and we are not exerting the kind of global leadership that people I meet all over the world actually long for us to exert again.

I’ll leave it to others to analyze why we are in such a problematic position, but in part, it may be because we continue to think in terms of American exceptionalism and the assumption that we always have been and always will be number one. I have a different definition of American exceptionalism and it’s this: we are number one except when we’re number 66, 11, 16, 22, 24, 27 or even 48. Indeed we are number six in global innovation-based competitiveness. I can’t believe this one, but we are eleventh in the percentage of our young adults who have completed high school. We are number 16 in college completion rates among the major nations. We are number 22 in broadband internet access for our citizens, number 24 in life expectancy at birth, number 27 in the fraction of our college graduates who earn science or engineering degrees. While I know this is highly subjective, we are number 48 in the quality of K-12 math and science education.

We have a huge national agenda that is not being tended to, but for now, let me stick to universities because if they do not remain healthy, we don’t have a prayer of getting back on track for the long haul.

I’m very concerned about the financial pressures, especially on public universities and their
long-term effect on accessibility. Even before the financial tsunamis that our country has endured in the last few years, the overall correlation of college attendance with family income had become troubling. Consider the relationship between college attendance and high school achievement. Data are available about preparation in mathematics. They can reasonably be expected to serve as a proxy for high school academic achievement more broadly.

Further, let us define for the moment low income families as those who earn less than $30,000 a year and define high income families as those who earn more than $100,000 annually. What has been found is that 80% of the high achieving kids from low income families attend college. That’s actually good, but what is perplexing is that this is essentially equal to the percentage of low achieving but high income kids who attend college. In other words, as far as college enrollment is concerned, it’s just as good to be a low achieving wealthy kid as to be a high achieving poor kid. This does not describe the kind of need-blind meritocracy that our country should strive for.

“I’m very concerned about the financial pressures, especially on public universities and their long-term effect on accessibility.”

Now think about the pressures on universities. In the last decade, I need not tell this audience the real state appropriation to public colleges and universities across the nation per student dropped about 20% overall, but the total cost to students and their family of attending a state university during this period increased by 52%. Such declining state support and the resulting in tuition increases may even make sense in the near term, but it’s not a sustainable situation.

One highly exacerbating reaction to this situation is increasing the amount or use of so-called merit-based financial aid rather than the need-based financial aid. A second likely reaction will be to cut back on course offerings or majors or curricula that have low numerical demand. A likely consequence also may be that we simply have fewer students from lower-middle and low income families.

Next, think about the most common way in which universities address the devastating loss of state revenues to support undergraduate education. Here it is, at least in my view: a university located in State A, what does it do? It increases the number of students it enrolls who are residents of State B. Why? Because they can easily charge substantially higher tuitions for such out of State students. Now of course the universities in State B also are suffering from seriously decreased State appropriations, so they will seek to enroll more high-paying students from State A. This interchange of students will increase the geographic diversity of our student bodies, which arguably has educational benefits, but it inevitably will also drive up the average family wealth of students at both states and both universities. It’s also likely that it will devote even more financial aid from the needy students to high-achieving but well-to-do students. If this spiral should continue rapidly upward, I think it will be a big setback for our belief in the importance of access to good education.

Our noble aspirations have always been, in my view, well characterized by the motto adopted by the University of Michigan in the 19th century: “An uncommon education for the
common man.” The architect of the American research university as the primary institution funded by the federal government to perform the nation’s basic research was Vannevar Bush. Vannevar Bush, former engineering dean and vice president of MIT, headed the OSRD, the Office of Scientific Research and Development that coordinated our nation’s R&D establishments together with industry to serve the national effort during WWII. Near the end of the war, at President Roosevelt’s request, he drafted the now famous report *Science, The Endless Frontier*. This report is remembered because it set out a plan to build our national research infrastructure within our universities. This was a radical idea at the time. No other country had taken this approach. *Science, The Endless Frontier* however also proposed the establishment of The National Science Foundation.

Suppose our goal has three parts. First, maintain access to our universities for bright and motivated students regardless of their financial means. Two, do this with diminished state funding, and three, maintain excellence in our universities. If these are our goals and realities, then we have to somehow increase our educational productivity. The “p” word, productivity, is something from which we academics instinctively recoil, but the fact is that in the long run, if we are to retain access in an era of restrained resources, somehow it does have to go up, but we must mean something by productivity that is more sophisticated than simply increasing class sizes and cutting out subjects. We need to improve all the outputs of education such as learning, critical reasoning, creativity, time to degree, life-long learning skills and so forth.

One important path surely is to explore higher levels of using information technology. What do I mean by “higher levels”? With that term I’m trying to signal that we need to do much more than just deliver canned courses to the desktop computer. We need to develop systems that provide personalized learning to our on-campus students and engage faculty as true guides and teachers for those elements that cannot be enhanced through the use of IT. It will not work for all subject matter. It must be structured and developed using serious knowledge from cognitive science and human learning processes. Such approaches to personalize machine-enhanced learning are beginning to appear, but they need to be really thoroughly evaluated, understood and improved, but the first goal should be to improve learning. If that goal can be achieved, then chances are good that costs can be lowered as well. We must aggressively explore this at scale.

“**Our nation today is wandering in a social and political wilderness and could easily lose sight of how essential our research universities are to our future economy, health, security and quality of life.**

But the point I want to make today is that there was another profound element of Vannevar Bush’s vision. In this report he wrote, “If ability and not the circumstance of family fortune determines who shall receive higher education, then we shall be assured of constantly improving quality at every level of scientific activity.” I think this is a very important statement that, to me, is every bit as profound and as important as the vision he laid out for the conduct of research. Today we must strive to heed this part of Vannevar Bush’s vision as well as to work to keep the research enterprise strongly funded.
My remarks today have focused largely on the American research university from a national perspective. This is because the institution that we value so deeply is under financial stress. It is also because our nation today is wandering in a social and political wilderness and could easily lose sight of how essential our research universities are to our future economy, health, security and quality of life. We could easily slip back into a circumstance in which higher education and research are pastimes for the wealthy rather the means to a better life across the socioeconomic spectrum, but even as we address these critically important national issues, we must keep our sights and values even higher and strive to be good citizens of the world as well as the U.S. We must contribute to and learn from increasing globalization of higher education.

We live in an age characterized by two opposing trends: integration and fragmentation. Because of modern travel, commerce, communications, all regions and all peoples of the earth are increasingly linked and integrated. We are linked and integrated also simply because we inhabit a single planet. We share its fragile environment. We share its ecosystems and finite resources. We are linked and integrated by a common desire of people everywhere to live peacefully and in good health. We are linked and integrated by our common curiosity about the world, the universe and each other. We are linked by the knowledge and understanding developed by many people in many places in many periods of history. Yet at the same time, forces, new and old, cause us to fragment, to divide ourselves along fault lines of culture, history, geography, misunderstanding and fear of the unfamiliar.
Those of us gathered here today presumably share a common belief that the dominant trend of this age must be linkage and integration and not fragmentation. We believe that education, learning, discovery and creation of opportunity will bind us together and enable us to collectively build peace and prosperity and to face the challenges of living together on this earth. We believe that knowledge and its wise use will elevate the quality of life all around the world. We believe that science and technology can play a central role in this quest.

Indeed, the origins of the research university as we know it can be thought of as the first phase of globalization because, as you all know, the idea of combining advanced education and research was imported from Humboldt University in Germany by the Johns Hopkins University in the U.S. in the 19th century.

“Openness is the true spirit of education, democratization and empowerment. It underpins innovation, cooperation and competition worldwide.”

During the rest of the 19th century and the 20th century, the idea was refined, expanded and adapted to the new world here in the U.S. We developed both public and private research universities ranging from the great land grant universities to more focused institutions like MIT and Cal Tech. Then, amazingly, research universities propagated to Asia and ultimately back again to Europe in essentially the form developed here in the U.S.

Today research universities are being developed and transformed all over the world—in Asia, in India, in the Middle East, in Russia—largely as graduate institutions. This is a huge topic for another day, but let me make one observation. The scale of expansion planned for higher education in countries like India and China is simply beyond my imagination. The government of India speaks openly of establishing 800 to 1,000 new universities in the coming decade. It is very difficult for me to even contemplate anything of this scale, but I believe that the U.S. and India for example, must learn from each other because I suspect that the strategies that will make fast expansions possible in India will be closely related to the strategies that are needed to increase productivity and sustain access in American universities.

In the 21st century competition and cooperation are the yin and yang of globalization in higher education and in other domains. Competition among research universities worldwide simply drives excellence. Competition also signals that would should value diversity of institutional types, cultures and approaches, but we must also cooperate if we are to meet our shared challenges, use our finite resources well and advance our shared knowledge in humanity. Global cooperation and research will take many forms ranging from brain integration (as I called it) for solving complex problems to shared use of expensive facilities, often with access via cyber infrastructure. But global cooperation and learning and access to knowledge is more immediate and it must be built on a foundation of openness.

At MIT, I became passionate about sharing knowledge because the role of universities is to create opportunity and people everywhere need that opportunity. Indeed, the faculty of MIT established MIT open courseware and committed itself to putting their teaching materials for over 2,000 subjects on the World Wide Web for anyone to use, anywhere, anytime, free of charge. We learned that many people sought and valued this knowledge. It has been accessed all over the world by teachers and self-learners alike.
Other universities also have concluded that this is a good idea. Open courseware has now evolved from an MIT initiative to a global movement. Indeed, recent books such as *Abelard to Apple: The Fate of American Colleges and Universities* by Richard DeMillo and *Unlocking the Gates* by Taylor Walsh present this open courseware movement as the beginning of a revolution in global higher education.

There are of course many other examples now of freely or inexpensively available scholarly and teaching materials, library resources, online courses and other educational tools and even web-based laboratories.

In my view, this is all about openness and sharing of resources. Openness is the true spirit of education, democratization and empowerment. It underpins innovation, cooperation and competition worldwide. It enables sharing and accessing initially expensive and intellectually intensive materials. It speaks of institutional and national values. Of course, scholars have, for multiple centuries, shared knowledge and resources through books, journals and scholarly meetings, but what is new today is the scope, reach, speed and interaction suddenly made possible by the ubiquitous internet and World Wide Web.

Indeed, I think these changes are profound and that something very fundamental is happening. In the mid-20th century, Clark Kerr, whose vision and talent gave rise to California’s remarkable system of higher education, realized that the American research university had expanded and transformed into a multiversity encompassing fields of study and social purpose far beyond the historic traditions of universities.

Similarly, I believe that in the 21st century, what we are observing is the early emergence of a meta-university: a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced. The meta-university will enable, not replace, residential universities. It will bring cost efficiencies to institutions through shared development. It will be adaptable, not prescriptive. It will serve both teachers and learners. It will speed the propagation of high quality education and scholarship, build capacity for economic development, build bridges across cultures and political boundaries and be especially important to the developing world.

In closing, we must rekindle our national commitment to the research university as the prime provider of opportunity for a diverse population regardless of family wealth per states, per regions and our nation. Simultaneously, we must promote openness and provide leadership in openness, sharing and creation of opportunity for individuals and economies throughout the world.

Thank you very much for your attention.