



KAUST SYMPOSIUM

The Role of the Research University in the 21st Century

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Hilton Hotel
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KAUST Press

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Preface

The Custodian of the Two Holy Mosques King Abdullah bin Abdulaziz on October 21, 2007 led the historic groundbreaking event celebrating the birth of his long standing vision – King Abdullah University of Science and Technology (KAUST) in Thuwal, Saudi Arabia. The KAUST Symposium, an integral part of this momentous occasion, took place in nearby Jeddah, Saudi Arabia, the next day.

This publication constitutes the proceedings of the KAUST Symposium and represents the first of the scholarly publications of this new international university. The spirit of these events shaped the optimism, the enthusiasm, and the great hope for a new idea developing in the global academic community. Universities represent the preeminent contributors to scientific progress and human achievement. KAUST hopes to join this noble tradition.

At the KAUST Symposium, the great minds of the world's leading research universities present their thoughts on "**The Role of the Research University in the 21st Century.**" The speakers were the former presidents of Cornell University, Massachusetts Institute of Technology, and Ohio State University; the contemporary presidents of the University of California San Diego, King Fahd University of Petroleum and Minerals, Hong Kong University of Science and Technology, Technical University of Munich, Boston University, Institut Français du Pétrole, and King Abdul-Aziz City for Science and Technology (KACST); former vice president for research, University of Michigan; and the provost of Trinity College, Dublin.

In attendance to the symposium were academic, cultural, diplomatic, and business leaders from Saudi Arabia and across the globe, coming to share their ideas and showing support for the birth of KAUST. Their salient contributions were recorded in the question and answer dialogues present in this publication.

This symposium has revealed some of the basic conceptions critical to charting the new course that universities will take in this new century. These are ideas that will help to guide and chart KAUST's course as this new world-class international research university navigates through the universe of knowledge to create enduring scientific benefits for humanity and the environment of planet earth.

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About the Symposium

King Abdullah University of Science and Technology (KAUST) is envisioned to be a new model for the research university in the 21st century. With its world-scale groundbreaking ceremony marked by the presence of leading scientific and research institutions from across the globe, KAUST had the perfect opportunity to convene a symposium that will formulate the opinion of the world's scientific and research body about **"The Role of the Research University in the 21st Century."**

The symposium was held October 22, 2007 at the Jeddah Hilton under the patronage of His Excellency, Ali Al-Naimi, the Minister of Petroleum and Mineral Resources of Saudi Arabia. KAUST arranged for participation of distinguished speakers during the symposium and invited members from academia, research, industry, business, and opinion leaders from around the world to attend the symposium.

There were two sessions; the morning session addressed the historical and social aspects of the research university, while the afternoon session focused on the scientific and economic aspects. The keynote speaker and other presenters delivered their presentations and time was allowed for interaction and discussion with the audience. The symposium events were recorded and are available, electronically, as proceedings of the symposium.



His Excellency Ali I. Al-Naimi
*Minister of Petroleum
and Mineral Resources, Saudi Arabia*

Message

Dear Distinguished Guest,

It gives me great pleasure to welcome you today. This symposium marks the moment when KAUST assumes its role as a convener of great minds and generator of debate, a role that is central to the mission of all great universities, and one that KAUST aspires to fulfill.

KAUST is a singularly unique endeavor – to build a world-leading research university in less than a generation. The challenges are immense, yet the opportunities are even greater. The role of scientific research in solving the problems we face is more relevant than ever in the 21st century. How can a university like KAUST deliver the most impact and benefit to our nation and the world? What is the economic potential of this research? And what can we learn from history?

Our purpose today is to reflect on the past and consider what we can learn from the experience and achievements of others, both in this nation and far beyond its borders, and then plan with your help how to create, share, and utilize knowledge in such a way that we can provide a better future. Your expertise and your experience are invaluable in this and we welcome your participation.

Thank you for joining us for this important discussion. We are grateful by your support for KAUST and its mission, and we look forward to many more dialogues like this one.

With kind regards,

Ali I. Al-Naimi

KAUST Symposium Program

The Role of the Research University in the 21st Century Monday, October 22, 2007

- 7:00 – 8:30 **Breakfast** (for guests and spouses): Hilton Hall
- 8:30 – 8:40 **Introduction**
Mr. Ahmad Al-Khowaiter
Interim Provost, KAUST
- Welcome Remarks**
Mr. Nadhmi Al-Nasr
Interim President, KAUST
- 8:40 – 9:15 **Keynote Speech**
The Role of the Research University in the 21st Century:
Historical and Social Aspects
- Presenter:** **Dr. Charles M. Vest**
President Emeritus, MIT
Cambridge, Massachusetts, USA
- 9:15 – 9:30 **Break**
- 9:30–12:00 **Morning Presentations**
The Role of the Research University in the 21st Century:
Historical and Social Aspects
- Moderator:** **Dr. Frank H.T. Rhodes**
President Emeritus, Cornell University
Ithaca, New York, USA
- Presenters:** **Dr. Marye Anne Fox**
Chancellor, University of California, San Diego
San Diego, California, USA

Dr. Khaled S. Al-Sultan

Rector and CEO, King Fahd University of Petroleum and Minerals
Dhahran, Saudi Arabia

Dr. Paul Ching-Wu Chu

President, Hong Kong University of Science and Technology
Hong Kong

Dr. John Hegarty

Provost, Trinity College
Dublin, Ireland

Morning Question and Answer Session

12:00-13:30

Lunch: Hilton Hall

13:30-15:45

Afternoon Presentations

The Role of the Research University in the 21st Century:
Scientific and Economic Aspects

Moderator:

Dr. Fawwaz T. Ulaby

Past Vice President for Research
R. Jamison and Betty Williams Professor
of Electric Engineering and Computer Science
University of Michigan
Ann Arbor, Michigan, USA

Presenters:

Dr. Karen A. Holbrook

Past President, Ohio State University
Columbus, Ohio, USA

Dr. Wolfgang A. Herrmann

President, Technical University of Munich
Munich, Germany

Dr. Mohammed I. Al-Suwaiyel

President, King Abdul-Aziz City for Science and
Technology
Riyadh, Saudi Arabia

Dr. Olivier Appert

President, Institut Français du Pétrole
Paris, France

Dr. Robert A. Brown
President, Boston University
Boston, Massachusetts, USA

Afternoon Question and Answer Session

14:45 – 16:00

The Beginnings of KAUST
Mr. Abdallah S. Jum'ah
President and CEO, Saudi Aramco
Dhahran, Saudi Arabia

Concluding Remarks
Dr. Frank H.T. Rhodes
President Emeritus, Cornell University
Ithaca, New York, USA

16:00

Adjourn



Mr. Ahmad Al-Khowaiter
Interim Provost, KAUST
Jeddah, Saudi Arabia

Introduction

Distinguished guests, ladies and gentlemen, peace be upon you all. I would like to welcome you all to the first scientific symposium held under the auspices of the King Abdullah University of Science and Technology.

The subject of this symposium, "The Role of the Research University in the 21st Century," is a critical question for all of us, especially for those of us who have been working to develop this great university, inshallah. Now, I would like to present Interim President Nadhmi Al-Nasr who will give the welcome remarks.



Mr. Nadhmi Al-Nasr
Interim President, KAUST
Jeddah, Saudi Arabia

Welcome Remarks

Thank you, Mr. Al-Khowaiter. Friends, partners, ladies and gentlemen, let me, before I start my speech, first give His Excellency's regards to the symposium and to everyone here. He had to leave on an urgent matter out of the Kingdom last night. He was behind this symposium. He really felt so bad that he could not attend. He greatly supports the symposium and was very much involved in the details of the program. I know it is disappointing for him to miss it, but hopefully he will hear from us and from everyone here the success as we go through the symposium.

Let me welcome you to this historical event and tell you how honored we are by your presence. You represent 42 universities and 53 corporations and professional institutes from many countries, many scholarly backgrounds, professional skills, and personal convictions. You are men and women who have earned a notable place in the world of science and technology. We are truly honored by your presence, grateful for your interest, and eager for your cooperation, advice, and support.

Yesterday, we celebrated the noble vision of KAUST's founder and benefactor, the Custodian of the Two Holy Mosques King Abdullah bin Abdulaziz. We learned of his remarkable gifts and of the bold design and world-class facilities that are now under construction on this site, which is of such great symbolic significance, not only for the people of Saudi Arabia but for the people of the region and the people of the world.

Yesterday's emphasis was on the structural design and the physical facilities that will be provided for the campus of KAUST. What stunning design and what world-class facilities this involves. You will have an opportunity to see some of the plans whose bold designs match the broadness of the vision. You have already seen some of the transformations that will make the desert bloom in this new community of teaching and discovery.

Yesterday's gathering concentrated on the structural design. However, today's discussions will concentrate on the academic design on which KAUST will be built. Therefore, we invite you to join us, not simply in the discussions but also to embark with us on a journey of exploration and discovery, and to assist us in designing the intellectual framework which will be the hallmark of KAUST. We realize that both knowledge and technology are now global at a time when society itself is becoming increasingly global. That's why your presence today is of such great significance for us, and your participation is welcomed by all of us here in the Kingdom of Saudi Arabia.

The goal of KAUST is as simple as it is ambitious. It is to create here a new, independent, generously funded international community of men and women, open to individuals from all over the world from different backgrounds and from different faiths. These individuals will devote themselves to the pursuit of knowledge and its application to human needs. These needs are not only for the Kingdom of Saudi Arabia or our region, important as they are, but are also the needs of the larger world.

Yesterday's event was one of historical significance because of the King's personal engagement and continued commitment to this ambitious project. His role as a visionary founder, as a generous benefactor, and as Honorary Chairman of the Board of Trustees embraces the vision that he has articulated, underlies, and inspires today's event. As a leader of a nation that has a unique influence on the stage of world affairs, he now offers inspiration to the larger world, deciding to use its riches not only literally to power the nation and the world but also to empower its people with this university. This is an expression of the determination to use knowledge for the cause of human betterment, to create a community whose members will tackle some of the world's most demanding problems, and thus to promote understanding, progress, and peace.

Our purpose today, both this morning and this afternoon, is to reflect on the past and consider what we can learn from the experiences and achievements of others, both in this nation and far beyond its borders, and then plan with your help how to create, share, and utilize knowledge in such a way that we can provide a more secure human future. Your expertise and your experiences are invaluable in this, and we welcome your participation.

Today, the panelists, each of whom will be introduced later by the chairman of the two panels, represent the leaders from America, Asia, the Middle East, and Europe in the fields of education, science, and technology. They hold leadership positions in some of the world's most influential institutions, including universities, businesses, and professional societies. They bring individually and collectively unique skills and expertise, not only as scholars and professional practitioners but also as public servants and visionary leaders. Ladies and gentlemen, I wish you the best in today's symposium. I wish you the best during your stay in Saudi Arabia. You are the guests of this nation, and we are honored to be the hosts. Have a great day. Thank you.



Dr. Charles M. Vest
President Emeritus, MIT
Cambridge, Massachusetts, USA

Dr. Charles M. Vest will give the keynote speech. Dr. Vest is president emeritus and professor emeritus of mechanical engineering at the Massachusetts Institute of Technology. He earned his B.S. degree in mechanical engineering from West Virginia University, in 1963, and both his M.S. and Ph.D. degrees from the University of Michigan, in 1964 and 1967, respectively. He is the recipient of ten honorary doctoral degrees.

Dr. Vest served as president of the Massachusetts Institute of Technology from 1990 to 2004. During this time, he put special emphasis on enhancing undergraduate education, exploring new organizational forms to meet emerging directions in research and education, building a stronger international dimension into education and research programs, developing stronger relations with industry, and enhancing racial and cultural diversity at MIT.

Dr. Vest has worked to bring issues concerning education and research to broader public attention and to strengthen national policy on science, engineering, and education. He chaired the President's Advisory Committee on the Redesign of the Space Station and serves on the President's Committee of Advisors on Science and Technology. He chaired the U.S. Department of Energy Task Force on the future of DOE Science Programs, was vice chair of the Council on Competitiveness for eight years, and is a past chair of the Association of American Universities. Dr. Vest recently completed service as a member of the Commission on Intelligence Capabilities in United States regarding weapons of mass destruction and of the U.S. Secretary of Education's Commission on the Future of Higher Education. He now serves on the Department of State Secretary's Advisory Committee on Transformational Diplomacy and the Rice-Chertoff Secure Borders, Open Doors Advisory Board Subcommittee. He is the president of the National Academy of Engineering for the period of 2006 to 2012.

He is the author of two books on higher education and research policy, *Pursuing the Endless Frontier: Essays on MIT and the Role of the Research University* and *The American Research University: From World War II to Worldwide Web*. Dr. Vest is a life member of the MIT Corporation, the institute's board of trustees.

Keynote Speech

The Role of the Research University in the 21st Century: Historical and Social Aspects

Dr. Charles M. Vest
President Emeritus, MIT
Cambridge, Massachusetts, USA

Introduction

Excellencies, fellow academic colleagues, and ladies and gentlemen, it is an honor and an inspirational opportunity to participate in this symposium celebrating the establishment of the King Abdullah University of Science and Technology (KAUST). I foresee that later in this century we will look back on this day as a seminal moment in the history of higher education, and that we will salute the wisdom of those who conceived, implemented, and sustained the founding vision of KAUST.

Great universities seek to understand the past, engage the present, and shape the future. Universities that have a strong focus on science and technology have a particular responsibility to engage the present and shape the future, but they too must understand the past and learn its lessons. They must do so in order to clearly understand that they are at the core of the flow of human history and essential to human progress.

The Massachusetts Institute of Technology (MIT) that I have served for 17 years was established almost 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. Also 150 years ago, President Abraham Lincoln and the United States Congress chartered the National Academy of Sciences, whose subsequent evolution included the establishment of the National Academy of Engineering in 1964 in recognition of the centrality of engineering to the Age of Technology.

Today, in 2007, in the Kingdom of Saudi Arabia, KAUST has been founded to be a different

kind of institution to serve the purposes of the emerging Knowledge Age in the Kingdom, and indeed throughout our interconnected and interdependent world.

This is a noble and farsighted undertaking. It is also a voyage into the unknown. KAUST has set its compass by consulting widely and learning lessons from the experiences of great research universities throughout the world. But the founders of KAUST also understand the value of a fresh start, the uniqueness of its location, the necessity of its engagement with the world community, and its orientation toward the future.

Opportunity

Research universities create opportunity. They create opportunity for individual students by inspiring them, educating them, orienting them toward the future, teaching them that they are responsible for their own lives, and preparing them to advance the human condition. Research universities also create opportunities for industries, cities, nations, and regions by preparing educated citizens and by direct application of the new knowledge, new understandings, and new technologies that flow from their research and scholarship. Research universities create opportunities for our earth and for all people because knowledge and understanding pave the path to peace, and because scientific knowledge and engineering capabilities are essential for meeting the great global challenges of energy, water, environmental sustainability, food, health, and security.

Only through the lives, work, and leadership of those who are advantaged by education, research, and knowledge can we hope to advance the prosperity and quality of life of our world's population – a population that has doubled in my lifetime and may approach nine billion people by mid-century.

Globalization of the Research University

The structure and philosophy of the modern research university are largely derived from those developed at Humboldt University in Germany in the early 19th century. The essential element of the modern research university is its commitment to combining teaching and research in a single institution. This new approach to higher education migrated across the Atlantic Ocean and took root in the United States at the Johns Hopkins University. From there, it diffused across North America and throughout Europe as new universities were established and as research became a more central purpose of already mature universities. At each stage and location, the structure was modified and adapted to fit local contexts and purposes and to both lead and adapt to advancing knowledge and changing societal needs.

As the Age of Technology advanced in the second half of the 20th century, the research

university migrated and evolved further as is well symbolized by the establishment and rapid rise of the Indian Institutes of Technology and by the establishment or transformation of many research universities in Asia. This part of the journey of research universities is noteworthy because when each of them was established, its founders thoughtfully engaged the leaders of universities around the world to learn their lessons, understand their structure, governance, and operations, but also to adapt them to new contexts, to shape them for new ages, and to understand them as tools for creating new opportunities.

There are many lessons to be learned from this evolution, migration, and globalization of research universities. I would like to discuss six lessons that the research university of the 21st century can learn from the research university experience in the 20th century.

Lesson 1: Teaching and research must be intimately intertwined

Lesson 1 is that teaching and research must be intimately intertwined and must be assigned equal importance. Teaching and research are inseparable, and it is their synergy that defines the essence of a research university.

Many years ago, Fredrick Terman, then the provost of Stanford University, was asked whether he wanted Stanford to be a teaching institution 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 discovery as well as learning through teaching and exploration of the past.

In the long run, making universities exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details.

Lesson 2: The quality of a research university is determined by the quality of its faculty

Lesson 2 is that the quality of a research university can be no better than the quality of its faculty. The faculty defines the research university. The research university of the 21st century must strive to attract, nurture, and empower the very best professors. This essential task of building a world-class faculty will require commitment, fortitude, patience, and adherence to high-academic values as well as aspirations. Some well-experienced, excellent senior professors can and should be hired, but in the end it is also important that young faculty grow up through the ranks of the university.

Lesson 3: Science can flourish only in an open environment

Lesson 3 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 experiments, and validate theoretical conclusions. Science cannot be done in isolation. And, of course, interactions among scholars, scientists, and engineers who have diverse perspectives and varied experiences lead 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 or ideological forces.

Lesson 4: Young faculty must be free to study and teach what they believe is important

Lesson 4 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 research assistants to senior professors. The wisdom and perspective of senior scholars is important, but most dramatic new insights and innovations come from brilliant young men and women. But with great intellectual freedom comes equally great responsibility. Thus faculty, even early in their careers, must always be held to the highest academic standards, especially through the evaluation and constructive criticism inherent in the peer-review process. The freshness that comes from young faculty and from the continual flow of students to the institution is the key to a great research university.

Lesson 5: Competition engenders excellence in higher education

Lesson 5 is that competition – competition among universities to attract and retain the best faculty and 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 universities compete on a global scale. Nonetheless, competition drives improvements 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.

Lesson 6: Fundamental scholarship and research must exist on an equal plane with applied research and innovation

Lesson 6 is that fundamental scholarship and research must exist on an equal plane with applied research and innovation. As we enter the 21st century, we are

very aware that research universities create opportunity for nations and regions 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. Universities are places where ideas must be exchanged, evaluated, and integrated.

Even in a university like KAUST that is centered on science and technology, fundamental, curiosity-driven research conducted to discover truths about nature must play a central role equal to that of research that is applied quite directly to industry and to the solution of major problems facing humankind. At MIT, pure scholarship and research exist side by side, and, indeed, hand in hand with highly applied work. Both are conducted with mutual respect. Both are valued. Both are subjected to the same rigorous standards, and they inform each other. I believe this is one of the primary reasons that MIT grew to great stature in the world of universities.

The Role of Information Technology

The research university of the 21st century will be embedded in a world linked together by information technology. The development and global spread of the Internet and the worldwide web have fundamentally changed the ways in which we work and learn. I believe that openness and sharing of intellectual resources and teaching materials – not closely controlled point-to-point teaching at a distance – will emerge as a dominant ethos of global higher education. Sharing resources globally is a highly appropriate and natural application of the democratizing, liberating nature of the Internet and worldwide web.

Day-to-day communication and data transfer among scholars and researchers already are totally dominated by Internet communication. Virtual communities of researchers come together both formally and informally to collaborate, discuss, and even to remotely operate facilities such as large telescopes. Indeed, the world's cyber-infrastructure is now critically important to the conduct of scientific and engineering research.

Large, accessible scholarly digital archives are growing and heavily subscribed. MIT's OpenCourseWare Initiative makes the teaching materials for 1800 courses available on-line and free-of-charge for teachers and learners everywhere. From this beginning, an expansion of first-rate open-access teaching materials is developing in the United States, Asia, and Europe.

In my view, a global meta university is emerging. This meta university consists of the cyber-infrastructure, scholarly digital archives, open-access teaching materials, and virtual communities of scholars and researchers. It is the substrate on which the 21st-century research university will be built. Like the computer operating system Linux, knowledge creation and teaching at each university will be elevated by the efforts of a multitude of individuals and groups all over the world. The meta university will rapidly adapt to the changing learning styles of students who have grown up in a computationally rich environment. The greatest benefits of the meta university will accrue to developing nations because such shared resources can accelerate and reduce the cost of the development of new schools, colleges, and universities.

This meta university will develop because nation after nation is committed to enhancing and expanding their higher education, and because there are global efficiencies and economies of scale to be had by sharing high-quality materials and systems that collectively are too expensive for each institution to develop independently. This kind of sharing is not prescriptive, is not paternalistic, and it need not be politically or culturally laden because each individual institution, professor, or learner is free to use only those parts of the material he or she chooses, and may adapt, modify, or add to it in fulfillment of local needs, pedagogy, and context. Campuses will still be important, and universities will still compete for resources, faculty, students, and prestige, but they will do so on a digital platform of shared information, materials, and experience that will raise quality and access all around the world.

The Frontiers of Science and Engineering

We live in the most exciting era of science and technology in human history. This adds rich context and substance to the founding of KAUST. Recent decades have seen remarkable and rapid advances in the technological tools with which to do science. Science, in turn, has led to new technological products and processes.

Computational power and digital storage are ever accelerating as the number of transistors that can be inexpensively placed on a computer chip continues to follow what is known as Moore's Law by doubling every two years. We are progressing rapidly in our understanding of biology – the science of life – having developed deep knowledge of how individual cells function, discerned the structure of DNA, sequenced the human genome, and learned how organisms develop. Every day brings new insights into the nature of the human brain and mind, and we anticipate great advances in cognitive science and neuroscience in the 21st century.

This is a very exciting period for mathematics. In the last few decades, several long-standing mathematical puzzles have been resolved. Fermat's Last Theorem and Poincare's conjecture have been proven. New synergies between pure mathematics and computational mathematics have been established.

There is every reason to expect that, in the coming decades, physical science will also advance rapidly. We are likely to gain great insights into such cosmological mysteries as the nature of dark energy that is hypothesized to permeate the universe, dark matter whose unseen presence has been inferred, and gravitational waves that are as yet undetected but are expected fluctuations in Einstein's space time.

Today, there are two primary frontiers of engineering. One is the **bio/nano/info frontier**. This is the province of things that are becoming smaller and smaller, faster and faster, and more and more complex. The work at this frontier combines the power of physical science, life science, and information science. At this frontier, materials and devices are assembled by manipulating individual atoms. Here, the distinction between science and engineering has essentially disappeared. Many fundamental disciplines are required to work together, and progress is almost always made by teams of researchers, rather than by individuals. Developing the interdisciplinary organizations needed to work and learn at this frontier is critically important. The curricula of the research university of the 21st century must also reflect the interdependence and synergy of traditional disciplines.

The second frontier is the **macro systems frontier**. This is the province of things that are becoming large and larger, more and more complex, and that are of great societal importance. Work at this frontier advances humankind's agenda in energy, water, environment, food, sustainability, manufacturing, logistics, civil infrastructure, and security. The work at this frontier is mostly done by engineers, but to achieve great goals these engineers need to collaborate with colleagues from economics, management, the social sciences, law, public policy, and the arts and humanities. Organizing the collaborative structures and education needed to work and learn at this frontier is also critically important to the research university of the 21st century.

Much of the excitement and potential of the future of engineering will come from bridging these frontiers as nanoscale science, synthetic biology, biomimetics, etc., are applied to real needs of real people on a grand scale. New ways of designing and manufacturing materials that leave much smaller environmental footprints will be developed. Genetically engineered microorganisms will be used to convert cellulosic plant materials to new fuels for transportation needs. The time and cost of sequencing and analyzing the genomes of individual men and women will drop precipitously and make possible personalized, predictive medicine, i.e., detecting individual's susceptibility to specific diseases and treating them before they actually become ill.

Small-scale science and engineering will drive new approaches to our largest and most important systems. We will learn from nature how to become better engineers who use natural resources and energy much more sparingly and efficiently. We will also learn to use genetically engineered organisms to perform manufacturing operations and will use the beautiful and complex molecular structures found in nature as templates for engineered materials and systems that will find application in solving energy and environmental challenges.

Research universities produced some of the most profoundly important innovations of the 20th century. Among the innovations in which universities played the sole

or dominant role are computers, the laser, the Internet, the fundamentals of the Global Positioning System, numerically controlled machining, the organization and deployment of the worldwide web, financial engineering, the genetic revolution, and much of modern medicine.

We have every reason to believe that the research university of the 21st century will play an equally central, profound, and, indeed, indispensable role in the period of great innovation that lies ahead.

Excellence, Competition, and Cooperation

Earlier, I suggested that a key lesson from 20th-century research universities is that competition – competition among universities to attract and retain the best faculty and students and competition among professors and research groups in the free marketplace of ideas – engenders excellence. However, it is a paradox of this age that we all must cooperate as well as compete.

The 21st century is an age when we cannot compete nationalistically based on geography, natural resources, or military might. Nations, regions, and universities can only prosper and compete based on brainpower and innovation. Because brainpower and innovation know no political or geographic boundaries, the fact is we must all cooperate and compete. In my view, there is no domain of human activity in which global cooperation is more desirable than in education. It is in the interest of all people that education be available and effective worldwide. This includes the kind of “high-end” education conducted in research universities.

There are many emerging models for cooperation among research universities. A well-established university from one country can establish a campus or a research facility in another country. This can be very effective, especially in the near term, but unless very clear missions and strategies are mutually agreed upon, this may not be the best way to build and sustain intellectual infrastructure and excellence in the host country over the long run.

Institutions can form strategic alliances to which each partner brings something of value to the other partner. For example, a European university may form an alliance with an Asian university to study tropical diseases or indigenous plants and animals to which they would otherwise have no access. Of course, the faculty and students from both sides can share unique knowledge and scientific techniques.

Rather than physical presence, universities can cooperate by virtual presence, i.e., by distance education – the conduct of courses using Internet and television. This certainly has its role, but frequently becomes a one-way street rather than deep collaboration.

In my view, KAUST is proposing a rather unique model to meet its challenge of developing competitive forces for its research and advanced education through its Academic Excellence Alliances, Research Collaborations, Special Research Centers, Discovery Scholarships, and the King Abdullah Professorships and Scholar Awards. These programs, carefully, thoughtfully, and patiently administered will build a globally competitive university, and simultaneously will embed KAUST in fruitful international collaborations.

Conclusion

We live in an age characterized by two opposing trends – integration and fragmentation. Because of modern travel, commerce and communications of all regions and all peoples of the earth are increasingly linked and integrated. We are also linked and integrated because we inhabit a single planet. We share its thin and fragile environment. We share its ecosystems and its finite resources. We are linked and integrated by the 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 share a common belief that the dominant trend of this age must be linkage and integration, 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, and, indeed, essential role in this quest.

For this reason, we have much to celebrate as the King Abdullah University of Science and Technology is launched on its journey into the future. In this Knowledge Age, the research university of the 21st century can and must be a great force for enlightenment, for integration, and for prosperity. The research university of the 21st century should not flourish only in one nation, or on one continent, or in one region. It should grow and spread its good works in all regions and on behalf of all people.

So, it is with pride and humility that I participate in this celebration. I salute the vision of KAUST and look forward to its role in spreading the richness of research, advanced education, and opportunity to Saudi Arabia, to the Middle East, and throughout the world.



Dr. Frank H.T. Rhodes
President Emeritus, Cornell University
Ithaca, New York, USA

The moderator for the discussion this morning will be Dr. Frank H.T. Rhodes who was president of Cornell University from 1977 to 1995. When Dr. Rhodes retired as president of Cornell University on June 30, 1995, he was the longest-serving Ivy League president and a U.S. National Advocate for Education and Research. He played a significant role in the development of the National Science Policy under several presidents.

Dr. Rhodes is president emeritus and professor emeritus of geological sciences at Cornell. At commencement ceremonies in 1995, the Cornell Board of Trustees announced that the Cornell Theory Center was renamed the Frank H.T. Rhodes Hall. During his tenure as Cornell's president, research funding more than tripled from 88 million dollars in 1977 to more than 300 million dollars in 1993. Asian studies, super-computing, biotechnology, and nano-fabrication were four major initiatives. In addition, a successful 1.5-billion dollar capital campaign was completed. New buildings and facilities that were built during his presidency include the Super-Computing Center, the Statler Teaching Hotel, the Biotechnology Building, the Center for Theater Arts, the Nano-Fabrication Laboratory, athletic facilities, and others.

Dr. Rhodes holds 35 honorary degrees and is the recipient of the Bigsby Medal of the Geological Society, the Justin Morrill Award, the Higher Education Leadership Award, the Clark Kerr Medal of the University of California-Berkeley, and the Ian Campbell Medal of the American Geological Institute. He is a member of the American Academy of Arts and Sciences and currently serves as President of the American Philosophical Society.

Dr. Rhodes is a graduate of the University of Birmingham, England, from which he holds four degrees. He is a former Fulbright scholar and Fulbright distinguished fellow; a National Science Foundation senior visiting research fellow; a life fellow of Clare Hall, Cambridge; a visiting fellow of Trinity College, Oxford; and an honorary fellow of Robinson College, Cambridge, and the University of Wales.

Morning Session

**The Role of the Research University in the 21st Century:
Historical and Social Aspects**

Dr. Frank H. T. Rhodes

*President Emeritus, Cornell University
Ithaca, New York, USA*

Mr. Chairman, your Excellencies, honored colleagues, friends, and partners of KAUST, I want to add my congratulations to the congratulations already given by Dr. Vest and to thank him for the fine introduction to our symposium. We celebrate the great generosity and personal inspiration of the Custodian of the Two Holy Mosques.

I want also, Mr. Jum'ah, in your presence, to acknowledge the leadership of the Minister, His Excellency Ali Al-Naimi, who was not able to be with us today and to tell him and you what a debt this new university owes to his magnificent leadership. I want also to thank you, Mr. Jum'ah, as Chairman and Chief Executive Officer of Saudi Aramco, for the wonderful team you have provided for the planning of this new university and to acknowledge especially the role of Mr. Nadhmi Al-Nasr as Interim President and the colleagues he has assembled. Their leadership has been superb.

The university as a community of scholars had its foreshadowing in early Islamic contributions because the House of Wisdom, the Bayt-Al Hikma, was in many ways an antecedent of a university community. Around the leading mosques from the 8th to 14th centuries were assembled scholars, not only from within the nations of the Muslim world, but also from other lands. Their documents, materials, and translations from all over the world were gathered together for study and teaching was carried out in a variety of areas. Even the use we make today of Arabic numerals and the very word "algebra" are reminders of our indebtedness to early Islamic learning, as is the preservation of much of the heritage of Greece.

It was later, in 11th-century Europe, that the direct forerunners of the university in our present understanding of the word were created. Around cathedrals and cathedral schools, communities of scholars developed, concerned at first chiefly with the transmission of the learning and ministry of the church. But later, training for careers in law – first canon law and later civil law – became part of the responsibility

of these young universities, and over time this legal preparation also became the means for preparation and initiation into the broader areas of citizenship for the students of the universities. From their earliest days, these embryonic colleges and universities were communities, not simply of students, but also of masters. From the beginning, they were international in their membership, of both their student bodies and of their faculties.

In Western Europe, by the 12th and 13th centuries, a number of universities that still exist today came into existence including, for example, Milan, Bologna, Paris, Heidelberg, Oxford, Cambridge, and Edinburgh. Throughout Europe and later in North America other universities gradually came into existence over the following centuries, but the major expansion of universities in the West took place in the 19th century. At that time, there was throughout Europe and North America a flowering of higher education and a major expansion of the numbers of universities and colleges. This was made possible both from the contributions of individual benefactors and from state and national governments, and it contributed to the major expansion of learning, the growth and number of institutions, and a broad increase in access available to students. All these developments were based on the conviction that the universities should serve not only as repositories of ancient knowledge but also as a locus for the development of new training for the emerging professions and in the development of knowledge itself. Thus, secular governance and a secular emphasis on professional preparation replaced the earlier commitment of a clerical community devoted to more clerical ends.

Let me illustrate this development in the case of the United States, not in any sense implying this as prescriptive but rather as illustrative of the development of universities in the West. In the United States, the 19th century was a particularly important period, because it was wedded to the recognition by the federal government, led by Abraham Lincoln, that agriculture and the so-called "mechanic arts" were essential to the nation's future well-being and prosperity. Although individual, private institutions had come into existence over a longer period from the 17th century to the early 19th century, it was during the mid- to late-19th century that a host of now outstanding institutions came into being. Those that were public were supported by a grant of federal land, so that institutions were developed in every state of the Union in order to promote useful knowledge. This useful knowledge swept across the country in the creation and development of new institutions. And, though their purpose was new, all these new universities were still built around the ancient medieval model and structure inherited from the older universities of Western Europe.

The primacy of the disciplines (notice the very word "discipline" implying teaching disciplines or pathways) and departments became the foundation upon which the new universities were created. It was not until later in the 19th century that the Humboldtian concept was imported from Germany into the new Johns Hopkins University, emphasizing the role of the university, not simply as a repository of learning for existing knowledge but also as a community devoted to the pursuit of

knowledge itself. Thus knowledge was seen not only as a deposit but as a source of inquiry. It was because of this new emphasis that research and graduate education were added to the tasks of the university.

The 20th and 21st centuries have been times not only of social upheaval, but also of intellectual upheaval. We have seen a growing emphasis in the universities upon preparation for professional practice and upon social mobility. The availability of education to everyone able to benefit from it and research linked not only to knowledge for its own sake but also to economic development continues to have a transforming influence on the university. The effect of these developments has been hugely beneficial, not only for the regions and nations represented by the great research universities but also to the larger world.

Let me turn again to the United States experience to illustrate some of the features and characteristics that have been critical to the success of the universities, and especially to their public contribution to economic development and social life and well-being. The first is that the institutional autonomy of the universities and the independence of their governance have proved to be absolutely critical for their success. KAUST is fortunate to be an independent university, having its own board of trustees responsible for the oversight and well-being of the university. In those universities in any part of the world where the independence of university self-governance has been weakened or displaced, freedom of inquiry has languished and the institutions have floundered. There is still some tension in the public universities, both in Europe and in North America, between independence and institutional autonomy and the role of government. But in every case in which the issue has been tested, the autonomy of the institution has prevailed. Earlier in my career, I was honored to have been a faculty member and senior administrator at the University of Michigan, a truly great public university, where periodically the board of trustees have gone to court to challenge the right of the state to weaken the autonomy of the university. Let me say again that there can be no true university without independent governance. KAUST is remarkably fortunate to be established with an independent board of trustees.

The second feature is that the best universities have been able to preserve a commitment both to research and to teaching, with appropriate attention devoted to each. It has been said that research is to teaching as sin is to confession. Unless you participate in the former, you have nothing to say in the latter, for the two are inseparably linked. The early colleges were agents of teaching; the newer research universities are agents also of inquiry. Both demand attention.

The third feature of the great universities is that student admission is based upon merit, and substantial financial aid is available for well-qualified, able, and needy students. In earlier times, only those students with the ability to pay or the right connections were admitted, but now admissions are based upon merit. Such admissions are selective and competitive, and financial support is given in varying degrees based upon the degree of family need. But in virtually all cases, admissions

as well as appointments of faculty and staff are based on merit. Connections and family background play no role in these decisions. Performance and merit are the bases on which the decisions of admissions and appointments are made. The best universities rest on a foundation of meritocracy.

The fourth feature is one that I call "academic freedom." I use that phrase loosely because it is a term that is much misunderstood. I mean by it the freedom to study, to inquire, to explore, to challenge existing knowledge, to discuss, to debate, to express an opinion, and to publish – all without reservation or restraint. This is one of the fundamental foundations upon which the university depends. That freedom has again been severely tested over time in the West and in other institutions. But without such freedom there can be no true university. There is a paradox here because a successful university has an inherent tension between strong faculty governance, with the right of the faculty to determine its own affairs, and strong presidential leadership. The two are not contradictory but rather are complementary because the best universities require both strong faculty governance and strong presidential leadership.

There is another essential feature of successful universities. All enjoy secure financial support, although the balance and the proportions represented by that financial support are changing. It has been well said that if you think higher education is expensive, you should ponder the cost of ignorance. Overall, public financial support is declining while private financial support is becoming increasingly important to the future of the universities. But the combination of the two has always proved important to success. KAUST is fortunate to enjoy a strong financial foundation provided by the magnificent endowment gift of King Abdullah.

There is another feature of the best research universities. They are no longer local, regional, or even national in their influence and benefits. They participate in extensive partnerships and outreach far beyond the localities in which they exist and far beyond the regions and the nations of their origin. They are now global in nature and worldwide in their partnerships and influence. Again, KAUST is fortunate to have a flying start in this regard, with partnerships already created with many of the world's leading institutions. This pattern of partnerships will now be expanded by the virtual meta-university community that is rapidly emerging as a part of this new coalition. KAUST will enjoy the benefits of their partnerships to the fullest degree.

There is also increasing diversity and increasing internationalization among all leading universities. Earlier, Western universities were closed to women, ironic as that may now seem. Women now make up fifty percent or more of the students at both undergraduate and graduate levels of most universities, and a substantial portion of the senior administrators and faculty members in the universities in the United States are now female. Half the presidents of Ivy League universities, for example, are now women. Access to all members of the community – to women and to members of all ethnic and racial groups, including minority groups – has been deliberately increased, and is now a fact of life cherished by those who are members

of these larger communities. The continuing degree of internationalization reflects the same commitment. For all the benefits of the modern research universities, there are also a number of challenges that confront them. Let me mention some of these challenges.

The first challenge is that of supporting both a commitment to useful knowledge and also to humane learning. KAUST is to be deliberately devoted to the creation of useful knowledge, but we must ask the question of how useful knowledge is if it is not also humane. The great universities, including MIT and Caltech and others with a technological focus, have over time built into their programs a humane component. How to do that effectively is one of the major scholarly challenges for the university of the 21st century. The problem is that the growth in curriculum within the universities has produced a fragmentation of knowledge. You remember John Donne's lament at the time of the introduction of the Copernican view of the universe. He wrote of this new world, "T'is all in pieces, all cohesion gone." And that might serve as an epitaph for the fragmentation of knowledge in the modern research university. There is no center any more, and with this fragmentation in knowledge there has also come an increase in organizational rigidity with the separation of disciplines, one from another. The academic model of KAUST needs to address this.

A second problem that continues to concern universities in Europe and North America is that, at a time of increasing public demands for educational services of all kinds, there is declining public financial support for these activities. I do not know the situation in Asia, but I do know that this is a serious challenge. The cost of higher education continues to increase at a rate far beyond the rate of inflation, and this is a factor that has to be taken seriously by educational leaders themselves.

The final concern I want to mention is that of academic appointments, especially the complications of tenure. In most Western universities, a virtual lifelong appointment goes with every appointment to the faculty, and the result is that the faculty is a graying faculty. I hope I can say this without any disparagement, for these are men and women of the greatest ability. But many of these people became young faculty members during the boom years that followed World War II. These members of the baby boom generation will now be retiring in large numbers. Most research universities in the Western world will have to replace between a quarter and a third of their faculty members over the course of the next decade. This represents a major challenge, and there are severe constraints, not only in the number of individuals qualified to fill these positions but also in the difficulties of appointing younger professors in new and emerging disciplines even as these retirements take place.

In the face of these challenges and the organizational rigidities of almost all existing universities, KAUST enjoys enormous advantages and flexibility. First, KAUST starts with a modest size. Some of the largest universities in North America are institutions of 20,000, 30,000, and sometimes even 50,000 students. KAUST will be a manageable size. It can be made a real community. It has organizational flexibility. It starts with

none of the burdens of departments, colleges, and other organizational divisions that are part of the structure of traditional universities.

Second, it enjoys clear goals and a green field site without inheriting 19th-century buildings in need of constant maintenance, renovation, redesign, and renewal. It has a clean sheet, literally, to design its own future, to develop its own programs, and to develop its own site. And it has the resources to do it with imagination and flair. It is well endowed, and it is independent. What a wonderful start to have an endowment which is among the most substantial in the world and to have a board of trustees committed to independent governance and unfettered freedom of inquiry.

KAUST will also enjoy the benefits of well-compensated and well-supported flexible appointments. It will have partnerships with the greatest universities and leading corporations throughout the world. It will support a new kind of faculty member and a new style of engagement in a range of issues, not only of domestic or local concern but of international significance.

This leads us to a number of questions that I hope we shall explore as part of this discussion today and to which I hope our speakers will address their own experience.

First, is the broad organization proposed for KAUST the best we can devise, structured as it is around four major research themes and institutes, each supporting an array of research centers? Your advice here would be most helpful.

Second, what other areas should be added to those already envisioned? Are the four major strategic research areas, as now proposed, appropriate, or are there other obvious major areas which should also be included in the research portfolio?

Third, how do you humanize the present program? Can you have a true university without some presence of humanities or some affirmation of the very qualities that make us human? How dangerous is pure technology applied without humanity, compassion, and understanding? How important are the very things for which humanity itself must stand?

Adlai Stevenson, the former United States ambassador to the United Nations, once said at a Cornell celebration, and I hope Dr. Vest will forgive me, that "MIT humanizes the scientists, and Harvard scientizes the humanists, and Cornell succeeds in doing both." How can KAUST humanize the scientists and technologists? What should be the place of these humane concerns? Or what should be the role of something we once called the library? I do not mean the library in the traditional sense, but the library as a kind of intellectual commons, bringing together all members of the university around a common quest of learning and understanding. What is the library, or the intellectual commons, in the new kind of virtual university and in the new research community that is being created in KAUST? What is to be the center of common debate and discourse, and how do we share our common experience in

the way that university libraries of the 19th and 20th centuries once did?

Fifth, how do we encourage social concerns and commitments among our students? Should this be organized or should this simply be noted as desirable? What role should it play in the development of the university community?

Sixth, should the issue of sustainability be one that spreads across every aspect of the life and work of the university? No research will be significant unless we undertake it in the context of the sustainability of our larger society. How do we deal with the limited resources of the finite planet we share and with the problems of a continually increasing world population? How do we sustain the civilization we have built, and what role should this play across the spectrum of areas of concern of KAUST? If we cannot devise a sustainable model for our world community, we face the horrors of natural selection acting upon our own species. What role should KAUST play in this great quest for sustainability?

And finally, what advice can you give us about attracting faculty and students to this world-class institution? What do we need to do as we seek to make the dream a reality? The plan is in place, the resources are at hand, but how best can we go about it? How do we use the structural flexibility that King Abdullah and the Minister have given to us to undertake the creation of this new university? How do we best put into practice that flexibility as a benefit and not a liability? How do we maximize our partnerships, of which you are representatives? How do we engage and vitalize this new campus community? It is one thing to bring together 600 faculty and 2,000 research students. It is another thing to breathe life into the community in such a way that it is challenging and demanding – an exciting community of scholars, which we hope KAUST will become. How do we bring to reality the fullest benefits of KAUST to the Kingdom, the region, and the larger society? How do we translate inquiry and knowledge into application?

These are the questions with which I hope we can wrestle during the course of this symposium. The strategy is in place, but what are the tactics? We look for your help and advice. We welcome the rich experience and long institutional histories that you, who honor us by your presence at this gathering, represent.



Dr. Marye Anne Fox
Chancellor, University of California, San Diego
San Diego, California, USA

Dr. Marye Anne Fox is the seventh chancellor at the University of California, at San Diego. She is in her own right a chemist of international renown with great recognition and real distinction. She previously served as the twelfth chancellor of North Carolina State University and as distinguished university professor of chemistry, from 1998 to 2004. Before that, she was at the University of Texas at Austin as Waggoner Regents Chair in Chemistry and as vice president for research.

Dr. Fox received her B.S. from Notre Dame College and Ph.D. from Dartmouth College, both in chemistry. After a postdoctoral appointment at the University of Maryland, she joined the faculty of the University of Texas at Austin in 1976. Dr. Fox has taught chemistry courses ranging from lower division to advanced graduate levels. She was named by Texas' *Utmost* magazine as one of the "Best of UT Natural Science Faculty" and in 1986 won the college's Teaching Excellence Award. In 1996, she won Sigma Xi's Monie A. Ferst Award in recognition of outstanding graduate mentoring; so far, over 50 advanced degrees have been awarded under her supervision.

At the national level, she is a frequent lecturer on science education reform and acts as an advisor to the Association for Women in Science and BEST (Building Engineering & Science Talent). Dr. Fox is one of the most creative physical organic chemists, having published over 350 refereed papers, six books, and nearly 30 book chapters, mostly in organic photochemistry and electrochemistry.

She has been elected to membership in the National Academy of Sciences and the American Philosophical Society and as a fellow of the American Academy of Arts and Sciences and the American Association of Advancement of Science. From the American Chemical Society, she has received the Garvan Award and the Southwest Regional Award, and has been named an Arthur C. Cope Scholar. She has received many international research awards and was cited by *Esquire* magazine as "Best of the New Generation." She has been a Sloan Fellow and a Dreyfus Teacher-Scholar and is the recipient of six honorary degrees. She is a frequently invited speaker at international science conferences and has delivered more than 50 named lectures at universities in the United States and abroad.

I had the honor of first getting to know her many years ago when we served together as members of the National Science Board. She is now a member of President Bush's Council of Advisors on Science and Technology and chaired its panel on "Broadband Infrastructure for the 21st Century."

The Research University: Innovative Leadership for the Knowledge Economy

Dr. Marye Anne Fox

*Chancellor, University of California, San Diego
San Diego, California, USA*

Good morning, Excellencies and colleagues. Thank you for this great opportunity to be among the first to welcome KAUST into the international community of scholars. I am very pleased to have the opportunity to speak at this inaugural symposium and to attend the most impressive groundbreaking yesterday. I cannot express sufficiently our astonishment at how swiftly this outstanding university has been designed and is being built, seemingly right before our eyes. I congratulate the leadership team who are making this dream a reality.

I am flattered as well at the prospect of joining such a distinguished set of speakers. I am most grateful to be included. It is our fervent hope that the cooperation evident in today's ceremony will underlie every aspect of KAUST's development and that the world's scientific community will soon enthusiastically welcome a new partner with whom we can work efficiently at the frontiers of modern science and engineering.

I propose today to tell you about the first several decades of my home institution, the University of California at San Diego (UCSD), in the hope that lessons learned since its establishment may be useful to the academic leaders at KAUST. We are a young institution, less than 50 years old, and yet we consistently rank among the best public institutions in the world. Because UCSD has also been described as the youngest of the world's best public institutions, there may be similarities that would render us an appropriate model for our new sister institution, KAUST.

First and foremost, UCSD was founded as a graduate institution focusing on science and engineering. We enjoyed the great advantage of building on a tradition of excellence at the Scripps Institution of Oceanography, with a heavy emphasis of earth and climate science that to this day remains as a key part of the institution's persona. Founded in 1960 as one of the research universities comprising the University of California System, UCSD was able to attract the best faculty because of a combination of dedication to excellence, access to resources from a state populace that valued higher education, a determination by the federal government to bolster science in response to the then-recent launch of the Russian satellite Sputnik, and an institutional commitment to construct any infrastructure needed to do frontline science. And all of these assets were provided on a parcel of land adjacent to a unique natural seaport and one of the world's most beautiful coastlines. KAUST promises some of these same advantages.

Inspirational teaching and broad-based research dominate the mission of any high-quality university. But the modern research university, in addition, is innovative and thus contributes significantly to the knowledge economy. That is, the third foundation of any public university is public service – addressing pressing societal issues whose solutions can improve the quality of life of its citizens. Such service has evolved from working with professional societies, to participation in strengthening local elementary and secondary schools, to acting in an advisory capacity to local agencies, for example. In the last two decades, however, university service involves producing intellectual property that can be the basis for economic development.

What is the role of the research university in driving innovation? Economic development increasingly depends on knowledge generation. There is also a definitive link between fundamental research and commercial application. Universities that bring research and education together in an innovative way are those that succeed. What are the components of that success? First of all, research universities are inherently agents of change. Because they encourage change, they create new processes or products. In doing so, the individual research unit can spur economic development. In turn, the strongest research units attract the best resources, the most inventive talent, and the most revolutionary new businesses. As a result, top-quality research universities create jobs and attract new partners who enter jointly into this virtuous cycle.

University of California
San Diego

What is the role of the research institution in driving innovation and the knowledge-based economy?

- Research institutions are agents of change
- Spur economic development
- Strong research institutions attract resources and talent, new business and jobs







Figure 1. Logos of allied research institutions near UCSD.

Figure 1 displays the logos of several allied research institutions located within two miles of UCSD. Because of this proximity, we are able to exchange personnel, including students, and to cooperate in sharing instrumentation and library resources. This new

kind of collaboration encourages the scientists at collaborating institutions to apply jointly for research grants and to serve on each other's dissertation committees. This close interaction in turn leads to high technology innovation and an easier pathway to develop ideas for ultimate commercialization.

One measure of university innovation is the number of new products developed and the number of invention disclosures. According to the Association of University Technical Managers, universities in the United States have received as much as a billion dollars per year in royalties that derive from licenses granted in the fiscal year of 2000. They have spun out 462 companies, and seventy-five percent of those companies are located within the state in which the research was conducted. In 2002, universities took equity in fifty-six percent of these businesses.

Many universities take an equity position in new companies in order to provide a means for financing further development. A snapshot of the work being undertaken at UCSD might be helpful. Currently, we have 468 active U.S. patents that have resulted in license agreements with about 90 startup companies. UCSD has participated in collaborations with about 250 startup companies whose key products have depended on intellectual property generated at UCSD since the year 2000. These companies in turn have attracted others, leading to growth in the area and in companies with similar goals. As a result, the San Diego region is now acknowledged as one of the nation's most productive in both wireless technologies and in biotechnology. These concentrations constitute what Professor Michael Porter at the Harvard Business School describes as "clusters of innovation." Research spending increased substantially within these clusters as venture capital poured into the region.

The role of federal government has been very important in achieving these objectives because about one third of the research conducted in the United States is government-funded. Last year, UCSD conducted about 800 million dollars worth of federally sponsored research, placing us in the top ten of all institutions in the nation. Among medical schools in the United States, for example, per capita research investment at UCSD is ranked as number one. We are also dependent for support not only from the federal government, but also from the states. Federal support also facilitates private sector investment to attain successful private-public partnerships. Within the United States, the 50 states compete with each other for the best talent, causing high personal mobility around the country, as well as efficient transfer of intellectual property. States encourage their public institutions to actively promote innovation and they now use economic development as a key metric of success. A complete research portfolio therefore elicits support from not only federal and state government but also from industry and venture capital investors (Figure 2).

San Diego's regional economic development is affected, of course, by UCSD's monthly payroll of 81 million dollars, but it is also influenced by the economic impact of the innovation itself – jobs created, jobs replaced, and less innovative jobs being transformed into more innovative ones. Figure 3 shows the contributions

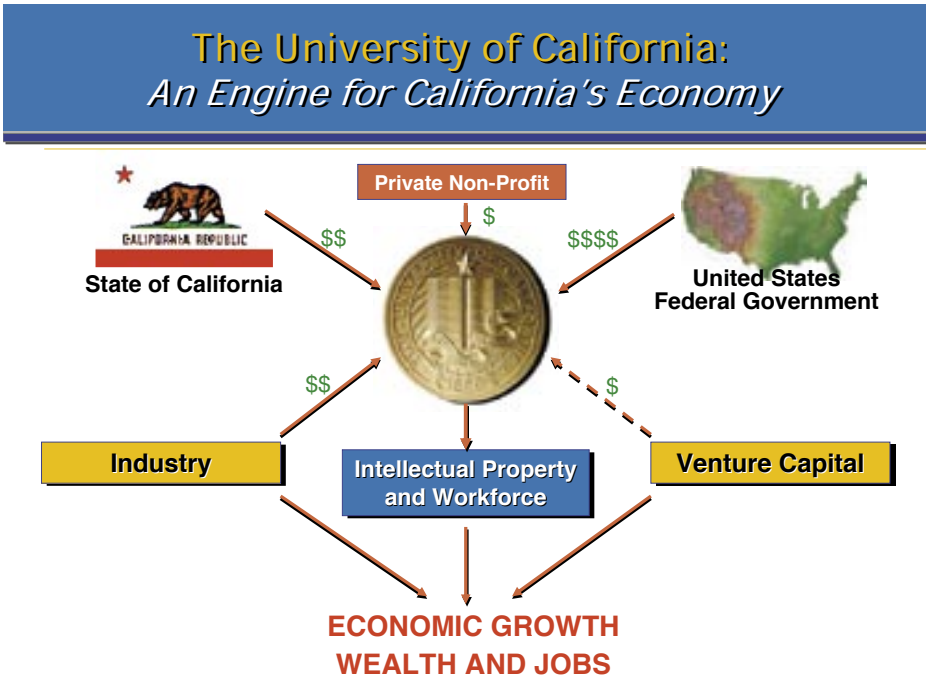


Figure 2. Public and private support for UCSD.

University of California **San Diego**

San Diego Cluster Employment

Industry Cluster	1990	2000	2002*
Biotechnology/Biomedical	18,785	29,312	30,527
Telecommunications	13,376	24,878	21,162
Electronics	21,583	24,169	18,843
Software	8,870	21,290	24,755
Defense Manufacturing	45,023	18,149	18,066
Others	239,070	309,815	306,347
TOTAL:	346,707	427,613	419,700

Figure 3. Employment industry clusters in San Diego County.

of defense-related manufacturing to the economic life of San Diego County as measured by jobs in each sector over the period from 1990 to 2002. Defense was a dominant industry in San Diego in 1990 because of its port and its proximity to major training areas and airfields. But by 2000, defense investment had been cut by more than half and, in its place, biotechnology was growing. At the same time, the telecommunications and electronics became increasingly significant factors. This industrial growth is exactly parallel to the trends in university research over the same period.



Figure 4. Conditions needed for developing technology clusters for a research university.

Why San Diego? One important factor is the effective locus that the university provides for research, for talent, for investment, and therefore collaboration (Figure 4). These same ingredients, of course, are inherent in the KAUST vision.

A graphic way to illustrate the effect of the research university on local economic development is shown in Figure 5. Here a map of the Torrey Pines mesa shows UCSD in purple. The collaborating research institutes developed as a rough circle around UCSD. Also note the position of San Diego State University (SDSU), an institution that focuses on teaching and workforce development rather than on research (at the bottom right). Notice that with a different commitment, SDSU does not have any of these collaborative institutions within easy driving distance.

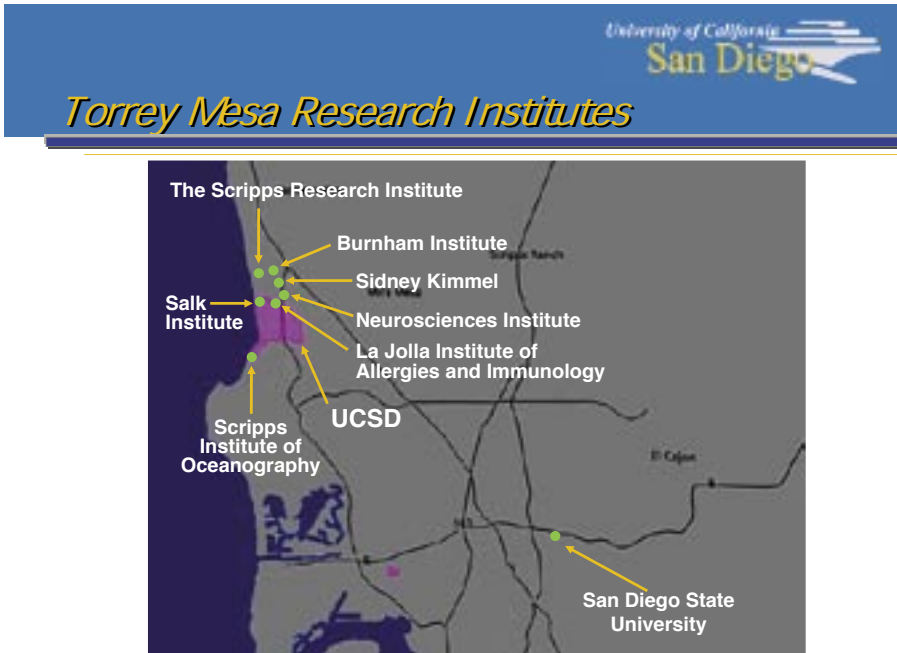


Figure 5. Research institutes near UCSD.

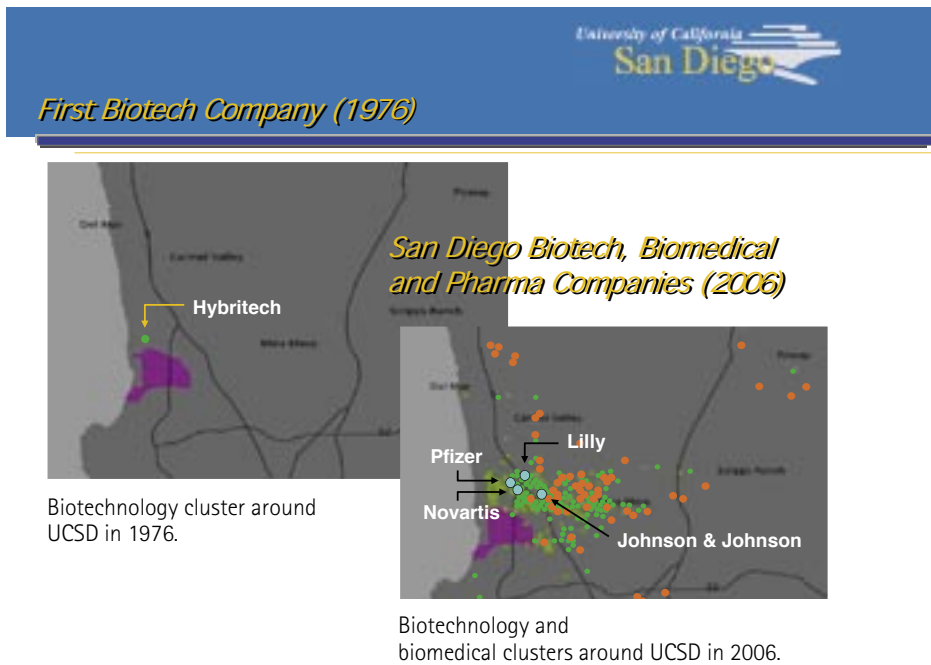


Figure 6. UCSD incubation of biotechnology companies.

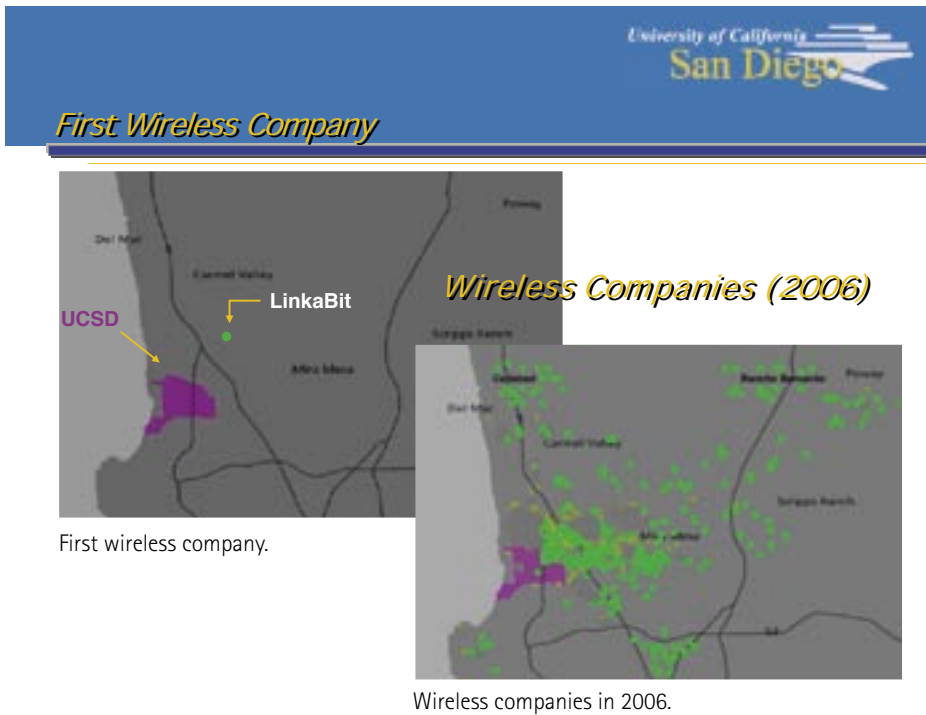


Figure 7. UCSD incubation of wireless companies.

Figure 6 shows what happened to the biotechnology cluster over the last 20 or so years. In 1976, there was one biotech company in San Diego County, Hybritech. At the bottom right is the comparable current graph in 2006, showing the placement of pharmaceutical companies, medical device companies, and a wide range of biomedical/biotechnical firms. Figure 7 shows similar growth in wireless communication. Starting from LinkaBit, a precursor to Qualcomm, the area rapidly developed a large concentration of wireless companies over only a couple of decades. The idea is that within the technology community, these companies depend on each other in many productive ways.

One critical feature in the successful transfer of new technology to the private sector for commercialization is an investment in infrastructure that allows development to transpire. Many of the inventors who led this amazing economic growth recognized the importance of the opportunity for life-long learning and for retraining across industries with different skill sets; that is, the university offers a convenient route by which very talented people could move efficiently from defense industries to emerging technologies. Through a program called UCSD Connect, ideas generated at the university were delivered to angel investors by newly trained graduates. In UCSD Connect, experts are called in to evaluate, on a confidential basis, the marketability of a new product or process. The group would then act as a matchmaker in bringing

together eager investors with entrepreneurial leaders. These deliverable products in turn allowed San Diego to attain regional innovative capacity that is so attractive to further investment.

One key question remains – how do universities strengthen a local or national economy? They do so by remaining true to their inherent mission – educating talented and inventive graduates, who devise truly excellent research agendas, and seeking to serve the supporting community. I believe that the same elements that have been proven to be so successful in San Diego are also inherent in the aspirations for KAUST. We are excited by the goals set by the KAUST leadership and look forward to fruitful collaborations to extend our cooperation even further.



Dr. Khaled S. Al-Sultan
*Rector and CEO, King Fahd University
of Minerals and Petroleum
Dhahran, Saudi Arabia*

Our next speaker is important to us because KAUST aims to be a partner with its sister institutions here in the Kingdom and will depend for its success not only their partnership but also healthy competition with them in advancing the needs of higher education.

Our next speaker His Excellency Dr. Khaled S. Al-Sultan is the third rector of King Fahd University of Petroleum and Minerals (KFUPM), in Dhahran, Saudi Arabia, and the first to have graduated from the institution to hold this post. He also has served as deputy minister for Educational Affairs.

Dr. Al-Sultan received a Ph.D. in industrial and operations engineering (operations research) and a M.S. in applied mathematics from the University of Michigan, Ann Arbor, in 1990. Prior to that, he obtained a M.S. in systems engineering in January 1987 and a B.S., with highest honor, in systems engineering in January 1985, both at KFUPM.

Dr. Al-Sultan was the dean of the College of Computer Science and Engineering from September 1996 to August 1998 and chairman of the Systems Engineering Department from June 1993 to August 1996 at KFUPM. He has served on editorial boards of several international journals, has published 40 papers in refereed journals, co-authored one book and four book chapters, and has attended numerous international conferences. He is a member of a number of international professional organizations and consultant for several government and private industrial institutions. Dr. Al-Sultan is now a member of the board of Saudi Aramco.

I have had the privilege of coming to know him as a member of the Advisory Council and I want to pay tribute to the cooperation and the guidance that he has given in the shaping of the agenda for KAUST.

Research Universities in Developing Countries: Role and Sustainability

Dr. Khaled S. Al-Sultan

*Rector and CEO, King Fahd University of Petroleum and Minerals
Dhahran, Saudi Arabia*

Let me just start by congratulating the Custodian of the Two Holy Mosques for the inauguration of the groundbreaking for KAUST and congratulate all Saudi citizens and the world for this initiative. Let me welcome all of our guests from all over the world to this symposium and also give congratulations to the KAUST group for organizing such an important symposium.

I will talk about the challenges for establishing research universities in the developing world. These research universities have been evolving over the past centuries. In particular, the modern university we know came probably from the idea of Wilhelm von Humboldt in Germany in 1818 when University of Berlin was established. The idea was if you establish a research university, you will develop the economy as well as the society of Germany, and the idea was successful. Later on, many German universities were established with the Humboldtian concept, and one particular thing about this model was that it introduced the idea of the "Chair" system – the appointment of discipline-based professors. This innovation helped to define the emerging scientific fields and also shaped the organization of the university.

There are a few things that are important to learn from this. Establishing a great research university takes decades rather than years. If we look at the third country that adapted the research universities, it was Japan. Now after two decades, if we look at the three largest economies of the world, we will see that they are the United States, Japan, and Germany. This shows that research universities are behind the growth of the economy. I would like to emphasize that apart or outside the United States and Japan, you rarely find a major research university. There are very few exceptions, but you rarely find a university that is private. Therefore, one has to rely on the government to support the establishment of research universities.

So why do we establish research universities in the developing world? The most important factor is to make sure that we give opportunities for the young generation to be educated in good schools. Research universities always offered good educational opportunities, especially for the master's degree and Ph.D. Research universities help increase the output of research, especially the research that is relevant to the country and the region. Research universities also help us build a scientific community, by producing more Ph.D.s and by retaining the researchers, retaining them from going abroad and keeping them in research universities from

taking other professions.

There are several questions that have to be raised before we establish a research university in the developing world. What are the educational and research needs of a country? What types of industry the country hopes for? Can we establish a research university in isolation – that it will be a stand-alone university without other universities being established afterwards? Will the competition be there? Can we establish research universities without mature industries? Is the research university supposed to lead or be part of the development?

Another important question is what type of public support do we need? As you all know, research universities are very resource intensive, and they are very costly to establish and run. So how can we justify establishing a research university for the public? Although that might be easier in the developed world, it will be very tough in the developing world.

What are the major challenges for establishing the research university in the developing world? The most important challenge is funding. If one compares the budget for some of North American universities, you will easily find that they are equivalent to some of the budgets of an entire third-world country. Therefore, you need a lot of money to establish the university and you need a lot of money to run that university – that question should always be there.

The question of flexibility and accountability – my colleagues have mentioned this about the freedom. The question of flexibility versus accountability is a very important question. You need to give a lot of flexibility for faculty to do whatever they want to do and to enter into the field of inquiry that they choose, yet you want to hold them accountable. In the developed world, this kind of culture is there in other setups other than the universities. In the developing world, the research university has to put a lot of effort developing that culture in the university. Competition for faculty and researchers is very tough now for universities, even in the developed world to compete for talented faculty. Now, if you go to the developing world where you establish a university, there are risks such as researchers and faculty have to usually move from their own country to the country where the university is established – that will be very tough. From our experiences in Saudi universities, we find that is the toughest part of all – being able to attract and retain quality faculty.

The faculty has to be given all the job security that is given in research universities in the developed world. And this is tenure, the track where the faculty is at ease and has job security so that he will be able to perform research work in areas of the unknown, to take some risky undertaking. At the same time, the faculty has to be responsible and be willing to be evaluated annually on his performance.

Competition for students is another challenge because there are limited numbers of mobile students all over the world and the quality of these good students. The top ones will always seek the prestigious universities to complete their advanced

degrees. But in most of the developing countries, the public school system does not deliver the quality of students that is needed for research universities. So whatever you do, if you do not get the quality of students that you like to get, then that will considerably affect the research university.

The question of changing agenda – do we have the flexibility and ability to change the course of areas as we go along when local priorities as well as international trends change? That is a question for third-world institution. Environment and research culture are very important. As I mentioned earlier, if you want to establish a good university, it has to or should help establish a cluster of industries around the university. In many developing countries where industries are not mature, how will this university flourish without having the right industries around it?

A very important question is the competition. Excellence is mostly derived from competition, and if you look at North American universities, you will find that most of the funding comes from outside where the faculty has to compete for funds. Now the question is even if you have enough money for a research university and faculty does not have to compete for funds, then in the end that will probably make them more complacent. So the question is how do we get more competition from faculty to get funds? This will probably involve more funding agencies within the country and more research universities within the country so that faculty is always on their toes to get more funds for their research projects.

Practical expectations are very important. Developing countries establishing such institutions are always expecting results within months or years. They do not want to wait for decades to see results, although we know that research universities need time to produce results. Unfortunately, this puts more pressure on faculty to work on what they already know rather than to work on the unknowns. This type of impractical expectations has to be toned down and people have to know that these projects work on the decade level rather than the year level.

With all of these challenges, the picture is not as bad for Saudi Arabia. We have a few things that are different. The most important one is the political will of our leadership. Most of you attended the groundbreaking yesterday and you saw the King speaking from his heart. KAUST is only one of many initiatives for education. Some of you know the great King Abdullah Scholarship Program where we are sending tens of thousands of students abroad, establishing many regional universities, and a lot of other initiatives. We are not lacking the political will for that. I should not say "plentiful" but we have good financial resources. As you know, KAUST is a well-endowed university. The Kingdom also has some uniqueness in the sense that it can attract more Muslims, Arabs, and Middle Easterners in general because of other non-academic reasons. That will probably make us more of a magnet for some of the people around this region. We do have some mature industries especially oil, gas, and petrochemicals that definitely will provide opportunities for research universities, especially KAUST, to develop, benefit, and utilize them.

In the Kingdom today, we do feel more that research is a must. If you spoke to people probably two decades ago, they, including some of the top officials, would have thought that research is a luxury. That is not true anymore in Saudi Arabia. People now think that it is a must. You can see that more spending is now on research and development, both in the private and public sectors. But there is still the under-utilized female talent, although we do have wonderful achieving women around the Kingdom. A research university will give them more chance to pursue their advanced degrees and to become faculty and researchers in that university. Our little experience with women who have obtained their advanced degrees has shown they have done a wonderful job. Let me just mention this figure – in 1970, we used to have only six women in higher education; this year sixty-two percent of higher education students are females and we are proud of that.

We have established many initiatives in recent years. One is the science and technology initiative strategy. We are establishing a higher education plan for the next 25 years as well as building economic cities around the Kingdom. These many initiatives will help to make it easier to establish a research university in Saudi Arabia.

Lastly, I will just mention that at King Fahd University of Petroleum and Minerals (KFUPM), with limited resources and reasonable flexibility, we have been able to make some dents. We have been able to do research in engineering with ISI-ranked publications. We are ranked one of the one hundred top universities in research and engineering. We have been able to support our industries especially gas, oil, and petrochemicals. Our research institute enjoys a high reputation, not only in the Kingdom but in the region. We have also been able, when we talk about the educational part of the research university, to deliver quality undergraduate and graduate students to work in the important industries, often led by graduates of KFUPM. The question is – if that can be done at KFUPM with limited resources, I think KAUST has a good opportunity to be a great institution in the world.



Dr. Paul Ching-Wu Chu
*President, Hong Kong University
of Science and Technology
Hong Kong*

Dr. Paul Ching-Wu Chu joined Hong Kong University of Science and Technology (HKUST) as president and professor of physics in July 2001. He is a graduate of the University of Taiwan, Fordham, and the University of California at San Diego. It is no coincidence, perhaps, that Dr. Marye Anne Fox represents that institution today. He is a former research scientist at Bell Laboratories. It is striking how these great institutions, both industrial and academic, keep on producing great graduates. You will hear this recurring theme for several of the speakers.

Dr. Chu received his B.S. degree from Cheng-Kung University, in Taiwan. He earned his M.S. degree from Fordham University, New York, and completed his Ph.D. degree at the University of California, at San Diego. All of his three degrees are in physics.

After two years of industrial research with Bell Laboratories at Murray Hill, New Jersey, Dr. Chu was appointed assistant professor of physics at Cleveland State University. He was subsequently promoted to associate professor and professor of physics. He later took up an appointment as professor of physics at the University of Houston and became founding director of the Texas Center for Superconductivity. He has served as the TLL Temple Chair of Science at the same university since 1987. He also served as a consultant and visiting staff member at Bell Laboratories, Los Alamos Scientific Laboratory, the Marshall Space Flight Center, Argonne National Laboratory, and DuPont at various times.

Dr. Chu has received numerous awards and honors for his outstanding work in superconductivity, including the U.S. National Medal of Science, the Comstock Award, and the International Prize for New Materials. He was an invited contributor to the White House National Millennium Time Capsule at the National Archives in 2000 and was selected the Best Researcher in the United States by *US News and World Report* in 1990. He is a member of the U.S. National Academy of Sciences, American Academy of Arts and Sciences, Chinese Academy of Sciences, Academia Sinica, the Academy of Sciences for the Developing World, and a fellow of the Russian Academy of Engineering.

In 2007, he was appointed as a member of the U.S. President's Committee on the National Medal of Science, responsible for the selection of recipients for this top scientific honor in the United States. His research activities extend beyond

superconductivity to magnetism and dielectrics. His work has resulted in the publication of more than 530 papers in refereed journals. Dr. Chu and his colleague M.K. Wu made the history discovery of superconductivity above the critical temperature of liquid nitrogen. Under his leadership, HKUST had a remarkable rejuvenation of its programs.

The Role of the Research University in the 21st Century: Historical and Social Aspects

Dr. Paul Ching-Wu Chu
*President, Hong Kong University
of Science and Technology
Hong Kong*

It is indeed a great honor and pleasure to be here to participate in the groundbreaking of KAUST and also to have the opportunity to share with you some of our thoughts and experience with a very young university in Asia, Hong Kong University of Science and Technology (HKUST).

I was extremely impressed by the vision for KAUST as proposed by King Abdullah. I feel that the vision is not just grand but also unprecedented and ambitious. According to the vision, he wants to build KAUST as a new house of wisdom, not just for the people in the Kingdom and in the Middle East but also for the people in the world. It will be one of the world's greatest institutions of research. He also realizes that vision without funding is hallucination. Therefore, he proposed to establish an endowment to provide all the resources that are needed to pursue the vision.

Additionally, he wants to create new models for research. Basically he will establish a mega university for the world, including both the real and the virtual parts. And I still remember in the 1960's when the late Clark Kerr, who was president of the University of California, proposed a mega university for California. That is why California now has a grand University of California system which consists of ten campuses and that more than half of them are among the best universities in the world. I believe KAUST will become an almighty mega university for the world, including both its real and the virtual components.

In this world, there is only one unchanging rule, and that is, the world is forever changing – and changing at an increasing pace. We have witnessed more changes in the last 100 years than the whole of previous human history. It has created wealth, fostered health, and brought well-being for us all. The driving force is neither economic nor political, but technical – technologies that flow directly from the discoveries in science. For instance, IT has changed the world. It has blurred the national boundaries and has delivered creativity and intellectual liberations, and everyone under the sun can compete in a level playing field. As a result, manpower has become the most valuable commodity. We are all talking about knowledge-based societies. We are talking about creativity and innovation. Therefore, universities become extremely important. It is the foundation of the brainpower and the engines of the 21st-century economy.

Every country talks about world-class universities, but what exactly is a world-class university? We all know that no country feels it can do without one. Unfortunately, no one knows exactly what it is and no one knows exactly how to get one. It is only a concept and very subjective in my view, but there is enough common ground for us to talk about it.

I feel that for a world-class university, one wants excellence in research, teaching, and public engagements to create new knowledge, to develop new technologies, and to educate leaders of tomorrow. We also need academic freedom as Dr. Frank Rhodes and previous speakers already have talked about. We need an atmosphere of intellectual excitement and autonomous and independent governance of the institutions. We need adequate facilities for academic work and adequate funding as already emphasized and mentioned by the previous speakers. We also need a free and tolerant society that allows every individual to test and expand human knowledge, even when a mistake is made. Character development and moral education is extremely important. I usually say that for unintelligent persons you do not have to worry about bad deeds they may do, but you have to worry about intelligent ones. Personal honor and trust are built on character and integrity, and these are the foundations of democracy in free-market societies. As Ben Franklin once said, "only virtuous people are capable of freedom."

We talked about the knowledge-based society which is characteristic of innovation and creativity. To create such a society, we need sufficient resources to support the endeavor, the freedom to create, the independence to think, and the steady flow of new bloods, that is, new students and young faculty members. This society should have a risk-taking culture with no stigma attached to failing and trying. To complete the process, we need an uncorrupted government coupled with an entrepreneur spirit, supported by financial markets and a venture-capital system. Innovation is a continuous process. New ideas and knowledge today quickly become irrelevant or common sense tomorrow; and new and independent ideas are always in great demand.

What I would like to share with you is a little bit of my experience at our young university, HKUST. Our vision is to build a leading university with significant international impact and strong local commitment. Globally, we want to be a world-class university at the cutting edge in all targeted areas of pursuit. Nationally, we want to be a leading university in China to contribute to the economic and social developments of the nation. Locally, we want to play a key role in partnerships with government, business, and industry in the development of Hong Kong as a knowledge-based society. Yesterday, I saw the plans for KAUST, which are extremely impressive and beautiful. This is how our university looks from the air (Figure 1), from the ocean (Figure 2), and from my office (Figure 3). I welcome all of you to come to Hong Kong to visit our university.



Figure 1. Hong Kong University of Science and Technology (HKUST) – from the air.



Figure 2. HKUST – from the sea.



Figure 3. HKUST – from Dr. Chu's office.

I can see some similarities and differences between KAUST and HKUST. The similarities are that we all share the same aspirations and visions. We are both young, although HKUST is already 16 years old. We are both small in size and focused in science and technology. But I agree with what Dr. Rhodes mentioned that we also need a human dimension in a university of science and technology. We should pay attention to technology transfer – to transfer basic knowledge to the market place. As a result, we have a school of business and management and a small graduate school for humanity and social science. The surroundings are similar for Hong Kong and Saudi Arabia in terms of the relatively high GDP per capita compared with their immediate neighboring countries or regions.

Both universities emphasize "glocalization," a new word for globalization and localization, although some thought it was a misspelling. We not only look into the world as a whole, but we also pay attention to the local society (Saudi Arabia for KAUST and Hong Kong for HKUST). There are some complementary differences between the two universities in terms of culture, history, and support – the Kingdom really provides KAUST with generous support to our great envy. As to the scope, KAUST looks at a much bigger scope than HKUST can afford, which is limited by resources. In view of the above, I believe that there exist ample opportunities for KAUST and HKUST to collaborate and learn from each other.

While we have done well in the first 15 years, "what should we do in the next 15 years?" was the question we asked ourselves at HKUST a few years ago. I would like to share with you a piece of information just received from my university – Financial Times yesterday released the world ranking of the EMBA Programs and HKUST/Kellogg was ranked #1 with Trium, HEC Paris/LSE/New York #2, and University of Pennsylvania #3 among other great schools.

In order to look into the next 15 years, and after lengthy discussions with our colleagues and stakeholders of the university, we have developed the HKUST Strategic Plan 2020 in 2005. By 2020, the university will be 30 years old. We want to transform HKUST to the next level of prestige and accomplishments – to become a major force in higher education in Hong Kong, China, and beyond and to be among the top 25 universities in the world. Transformation means advancing from competitiveness to a position of leadership; moving beyond high impact to maximum influence; integrating the unique research culture into postgraduate and undergraduate teaching and community outreach; and becoming a leading innovator in higher education in Hong Kong, Mainland, and beyond.

The strategic plan basically was developed based on the following four guiding principles. First, we want to continue our quest for excellence in teaching and research, which was given to us by the government 15 to 16 years ago. Second, we want to build on strengths that have been established in the last 16 years and to bring them to a higher level. Third, we want to strengthen our relationship with the Mainland because Hong Kong, after all, is part of China although with a different system. Finally, we want to further expand our relationships with the outside world.

Our strategic plan basically consists of the following specifics. As I mentioned, in research, we are focusing on our existing strengths achieved in the last 16 years, such as bioscience and technology, nanoscience and technology, information science and technology, environmental science and technology, and business and management research. At the same time, we keep our eyes open for new opportunities. We are carrying out our China initiatives by building the HKUST Fok Ying Tung Graduate School in Nansha and expanding our Institute of Education and Research in Shenzhen. Both places are in close proximity with Hong Kong across the border as shown in Figure 4.



Figure 4. Hong Kong and surrounding region.

The University is also hard at work on the restructuring of higher education in Hong Kong to change college from three years to four years and high school from four years to three years, so that it will match the higher education systems in the Mainland and North America. HKUST is actively building up both the hardware and software required to meet the needs of our future development. The higher education reform in Hong Kong offers ample opportunities for us to achieve our goals.

As to further expanding our relations with the outside world, the Institute for Advanced Study (IAS) is being established at HKUST. The IAS has received strong support from the Hong Kong government and strong endorsement from the Mainland government. This is in line with the desire of the Hong Kong government to become an educational hub for the region. It is patterned after the IAS at Princeton with the same vision but slightly different in the nature of work to be carried out and its relationships with the university and society. We want IAS at HKUST to be one of the world's leading centers of research and intellectual inquiry, to drive major advances and discoveries with its interdisciplinary research, to attract leading international scholars to Hong Kong to work in close partnerships with local academics, to become an academic center in Hong Kong, and to become a platform for the future scientific, technological, and economic developments of Hong Kong, China, and beyond.

We are also faced with lots of challenges in terms of faculty recruitment and retention, but there is one advantage for us in Hong Kong, that is, the China factor. China has possibly the world's largest talent pool today in terms of student recruitment and diversity balance. HKUST is in the right place at the right time. With the right people, HKUST should be able to scale new heights.



Dr. John Hegarty
*Provost, Trinity College
Dublin, Ireland*

Our next speaker is Dr. John Hegarty and he is provost of Trinity College, Dublin (TCD). The title provost is an ancient one. In fact, all of the academic titles in Western universities are taken from clerical appointments within the medieval church – provost, chancellor, dean, and rector are all such titles. But the provost at TCD, an ancient institution whose first provost was Archbishop Asher, is a name known to some of you. The provost is the chief executive officer. TCD is an ancient university which has undergone recent transformation, much of it under Dr. Hegarty's leadership.

Dr. Hegarty was elected as the 43rd provost in August 2001. Born in County Mayo, in 1948, he started his college career at St. Patrick's College, Maynooth, completing his Ph.D. in physics at University College, Galway. He was a postdoctoral fellow at the University of Wisconsin-Madison and, like Dr. Chu, was a research scientist at Bell Laboratories, in New Jersey.

Appointed professor of laser physics at Trinity College (1986-2001) and dean of research (1995-2000), he was also elected as a fellow of the college. He was adjunct professor, at University of Georgia, in the United States (1990-95) and visiting professor, at University of Tokyo and Sony Corporation in Japan (1995).

Dr. Hegarty is a member of the Royal Irish Academy, the American Physical Society, the American Optical Society, the Institute of Electronic and Electrical Engineers, and a fellow of the Institute of Physics.

The focus of his research is the study of light and its interaction with matter. That conceals the enormous practical impact of the studies on which he has embarked.

The Role of the Research University in the 21st Century: Historical and Social Aspects

Dr. John Hegarty
Provost, Trinity College
Dublin, Ireland

Your Excellencies, Chairman, fellow speakers, and distinguished guests, it is my great pleasure to be here in Jeddah on the occasion of this great milestone in the foundation of the King Abdullah University of Science and Technology.

In commenting on the role of the research university in the 21st century, I thought it would be useful to share with you the experience of Ireland, a small country of five million people, a country which over the last decade has invested heavily in research from a very low base. There are interesting parallels between this development and what is envisaged for KAUST. I will refer to my own university, Trinity College, Dublin, for examples of how the role of the university has changed and adapted.

Many of you have heard of the dramatic economic and social transformation of Ireland. Over the last 50 years, the economy has changed from being heavily dependent on agriculture to becoming intensely knowledge-based, and Irish society, once quite insular, is now very open and confident. Over the last 15 years, a pattern of emigration stretching back over 200 years has been replaced by net immigration; instead of high unemployment, as high as eighteen percent in the 1980's, there is now a shortage of skills. For Ireland, the arrival of the "Celtic Tiger" signaled the prime importance of knowledge for economic, social, and cultural development and for sustainability.

Ireland's economic success has been the result of many factors. However, it is generally recognized that investment in education over many generations, and the central role of the universities, has been most pivotal. In a short period, universities have had to change from being mainly undergraduate to being research intensive and to redefine their mission quite radically. It is widely accepted by all of Ireland's universities that our mission involves making education and knowledge work for a healthy, wealthy, and wise society, helping a newly successful Ireland be an effective global citizen and ensuring that the present society is fully aware of its history and understands other cultures.

In meeting this new challenge, there are a number of factors that have helped Irish universities transform in a very short time. All are based on the principle that, in a research-intensive university, teaching and learning are intimately and inexorably linked with research and scholarship and that excellence in research is the starting

point from which flows innovative teaching, creative and flexible graduates, and the knowledge which will fuel new technology and social development. In particular, it is research excellence that enables the university to attract and retain the best academic staffs in the world who, in turn, are creative scholars and inspiring teachers.

First is the importance of the university as a living community. The university should be more than just a campus where students acquire information and knowledge. It should be a community of experience where students are encouraged to create their own environment for civic engagement, experimenting with life, and learning and developing values. Social development outside of the classroom and outside of research labs is fundamental to acquiring a breadth of outlook. It is self-organizing in many respects by the students themselves. In Trinity, we have a tremendous spirit of volunteerism among our students. They know they are privileged, they know they are living in a time when they are experiencing great advantage, and they also realize that they need to give back something because of that.

Second is the recognition that universities must deliver research to world-class standards. In a country where all universities are relatively small, this has involved prioritization and the build-up of strengths in selected areas, and a focus on inter-disciplinarity within a broad base of disciplines.

Third is the concept of partnership to achieve research excellence – between universities nationally and internationally, with business and industry, and with government. In this way, critical mass has been possible in key areas of the sciences and the humanities, a channel for the deployment of knowledge to the market place is built-in, student experience is broadened, and government has felt comfortable investing unprecedented resources in research.

Finally, the transformation of Irish universities to being research intensive in a short time has been enabled by philanthropy, and in particular by a son of Irish emigrants to the United States. Chuck Feeney and his philanthropic foundation, Atlantic Philanthropies, took the initiative some years ago to help develop a world-class research infrastructure in Irish universities. His action was a catalyst which resulted in the Irish government matching his contribution.

I strongly believe that it is the combination of these factors that is underpinning the strong role of universities in Ireland's development. We are now applying the model to all of our major initiatives across the sciences and humanities. I will give one example from my own university which demonstrates how this combination works in practice.

Recently, Trinity College opened a new state-of-the-art science facility, the Naughton Institute, which houses two compelling initiatives. One is Ireland's first purpose-built nanoscience research institute, the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), and the other is the world's first Science

Gallery. The development towards this institute is worth noting. Beginning in 1999, the government and Atlantic Philanthropies made a joint investment in physics and chemistry for a program in nanoscience. In 2003, the government, through the Science Foundation Ireland, made a major investment in academic leaders in the area and in a program involving Intel, HP, and other Irish universities. In 2007, a philanthropic contribution along with further government and private investments resulted in the building of the Naughton Institute, housing 130 researchers of over thirty nationalities and at a total cost of 100 million euro to date for people and capital. As a result, Ireland has recently been ranked sixth in the world in nanoscience in terms of citations per published scientific paper. Two spin-off companies have already been created. The Institute's other flagship national initiative, the Science Gallery, is a new outreach concept to bring the public and the scientists together through exhibitions and debates to address issues of major public scientific concern. The Naughton Institute is a result of complex partnerships and is now a model for all of Trinity College's future major developments.

I believe that the model of inter-disciplinarity – collaboration with other universities nationally and internationally, partnership with industry and with philanthropists, and outreach to engage the public – is the model most suitable for a small country with limited natural resources. It may well be a model that KAUST might want to consider as it develops.

In closing, I would like to highlight one other factor that I believe is important to all great universities, a balance between the humanities and the sciences across a wide sweep of disciplines and across the breadth of human knowledge and experience. Students learn best in this broad environment even if they specialize. KAUST, as one of the world's most far-sighted initiatives, is being established to specialize in graduate-level science and technology with major global outreach. It also has a great opportunity to embrace certain aspects of the humanities, especially in the use of technology to access the great heritage and traditions of the Islamic world and in promoting understanding across cultures.

I would like to take this opportunity to congratulate King Abdullah on this innovative and visionary initiative which holds so much promise for the discoveries of the future and for the people of the Kingdom of Saudi Arabia and the wider world.

Question and Answer Session

Question

Mark Desal, I am with Cisco and the question is to Dr. Fox. I thought it was quite interesting the little dots you had around your university and the value chain that you have created by innovation, research innovation, venture capital, and eventually IPO's and other things. I would like you to comment on this, and particularly as we look to KAUST, what could be a model for this country?

Answer

Dr. Fox: Thank you for the question. It is very important to know that these were personal relationships first that developed into geometrical, geographic determinations and emerging opportunities very close to the university. Often the scientists and engineers who participate in leadership roles in that context are adjunct professors or lecturers. They communicate back and forth and they provide internships, scholarships for students, and sponsor post-doctoral fellows. And, of course, there are also philanthropists because they are grateful to the university generally. It was a major factor in the conclusion of a billion dollar campaign just recently. I believe that the example we have shown suggests that knowledge well constructed from basic principles at a university in collaboration with a potential funder, typically a venture capitalist, can move the scheduled developments into delivery in such a way that there are local benefits. The university serves in many ways as an organizing principle and what kind of precedent that will develop for KAUST, I think the same things will prevail. There are, as has been mentioned several times, expertise here in petroleum refining and chemicals that do not exist elsewhere. Those could be the partners on which KAUST could develop. As innovative products come on to the market, KAUST will be able to respond and attract additional investments from the private sector and from government-sponsored research agencies. I would hope the same experience we have had in San Diego will retain there as well.

Question

My name is Mohammed Bakr, retired person, the president of MIT alumni in Saudi Arabia. First of all, let me thank all the panelists. They were all exceptional presentations and I have a question for Dr. Vest about the tenured versus non-

tenured program for KAUST. Will it be a successful model to maintain long-term research in Saudi Arabia by KAUST particularly if we abolish the tenure system?

Answer

Dr. Vest: I can always depend on my MIT alumni friends to ask really difficult questions. I want to express a personal opinion that is not based on intimate knowledge of the planning for KAUST. I must say that upfront. I am actually a great believer in the tenure system and the reason is two-fold. One is the traditional purpose of tenure which is to protect faculty from undue influence about the subjects that they study and teach in today's world remain important. The second thing is that those who, with good reasons, criticize the system tend to look at the far end, the graying that Dr. Rhodes referred to, of which I am a current participant. People tend to look at the far end of the tenure process and say, you are engaging in security and you are giving life-time careers to people who may not earn them in the real field of competition. But I find that as we look at the university experience to this point, the decisions that academics must make upfront about judging their younger colleagues after six, seven, and eight years of opportunity observing them are really important. It forces us to make difficult decisions about who should permanently or more or less permanently be part of our faculty that we might not make otherwise. In fact, I can say that, although I do not want to name the institutions, there are a few universities in the United States that abolished tenure as part of their units. Their experience over time seems to show that those units without tenure show the lowest turnover compared to those that do have tenure. I am always a great believer in experimentation, in trying new models. I really do wish a great success to KAUST and perhaps they will show us a new way, but I would urge some caution for overtime.

Question

I'm Bill Odell with HOK. If you found yourself suddenly the President of KAUST, what would be your number one concern to make this successful and what would be your highest priority?

Answer

Dr. Hegarty: I would say attracting the right caliber faculty is probably the one issue I would stay awake at nights, and it does go back a little bit to the issue of tenure. Perhaps I could just say from personal experience. Within Ireland, where there has been a huge investment in research over the last 10 years, the policy at the beginning was to attract the best people across the world for fixed periods with no long-term commitment. That seem like a good idea, but from experience,

I have not come across any of those people who did not look for a long-term commitment. This is purely a personal experience; faculty I would say is the key factor.

Dr. Chu: Yes, I think the most important ingredient that I will look for is the integrity, and also the trust and respect from future faculty members.

In terms of the tenure system, I just want to comment I voted for Dr. Vest. I think at this moment it plays a very important role to attract people. I do believe there may be some modifications needed in the future, and I hope KAUST can find that way.

Dr. Al-Sultan: Attracting faculty would be very important but I think attracting quality students will be even more important and more challenging. One does not know whether attracting quality students is more challenging than attracting faculty. In my opinion and knowing the area, maybe attracting the quality students will be even tougher than attracting quality faculty.

Dr. Fox: I would just add on the necessity of getting the very best faculty. As a beginning university, you have to have faculty that are not only highly productive and extremely intelligent, but they have to be dedicated to KAUST and to its ideals. So it is the sort of morality that Dr. Chu is talking about – they need to want to build the institution and want to use their intelligence to do that rather than to run isolated research groups which do not interact with rest of the institution.

Dr. Vest: I would concur that recruiting and sustaining the very best faculty and thereby the very best students is the major challenge. Also proving to the world that here in Saudi Arabia on the KAUST campus and community, you will truly be open to the diversity of people that would be required. That is probably what would keep me awake at night.

Question

My name is Ashraf Al-Khairi. I am with KACST which is the pre-transformation of KAUST. My question is addressed to the entire panel. If I may ask, should KAUST be a Saudi global university or a global Saudi university?

Answer

Dr. Vest: I believe it should be Saudi first and foremost. You will quickly learn that to serve Saudi well, you must be deeply interconnected with the world, global is a necessary condition to do that well.

Dr. Fox: I would agree that being a Saudi university contributes something that

is of great local importance. I also agree that being Saudi means including the women from the very start as well.

Dr. Al-Sultan: I think you cannot avoid the locals even if you want to be just international and global. You have to address local problems and you have to talk to local industries, so I think you need to be both Saudi and global.

Question

I am Sharifa Habsa Shahabudin, from National University in Malaysia. Firstly, I want to thank KAUST for inviting me to the symposium and the groundbreaking ceremony. I have one question and one comment. My first question is, for a new university like KAUST, it might be easy to identify the areas you want to work on. In a slightly older university like mine, which is 37 years old and now designated as a research university, we tried to strengthen our areas but we have many people doing research in various disciplines. The question is how do you try to be focused and integrate people who are working in different disciplines to strengthen four or five research areas in the university? The comment is I am glad to hear about the talent now – recruiting female talent in Saudi Arabia. In my university, we have seventy percent women enrolled in undergraduate programs, and more and more being enrolled in the postgraduate program. I am the 9th vice chancellor but the first female vice chancellor. My experience is that when we want the women to progress in academics, we have to balance their reproductive and productive roles. We do have to put in place some gender sensitive arrangements to help them balance this role so that they can be good researchers as faculty staff as well as looking after their family.

Answer

Dr. Fox: I think most of the best universities do provide gender-specific responses. It is not always women who require childcare arrangements.

Dr. Vest: It is my experience and observation that interdisciplinary teams have to be grown from the bottom up. It is very hard to dictate from the top down. The secret is very simple, namely that when there is a really interesting problem to be worked on and something that has great significance, people will work together in order to accomplish it. So, I think the art of leadership is a sort of putting these possibilities out there and pushing roadblocks out of the way and assisting the faculty, particularly the younger faculty who will want to work together to accomplish their purposes.

Dr. Hegarty: On the same point, given that this is a research university, the design of the Ph.D. program is probably the opportunity to build in disciplines. The tradition has been that the Ph.D. student has one supervisor and one mentor. I think broadening that out to having more than one would be a way to bring in

different disciplines. I think the biosciences may do that of its own accord, but it is interdisciplinary by nature in any case. We should never forget the fact that money is a powerful incentive. If you have money available with interdisciplinary action as requirement, it will help. People follow money.

Question

I'm Dr. Samar Sagaf, from King Abdulaziz University. First of all, I want to thank all the speakers. According to the fields of study at KAUST, we found concentrations in engineering, mathematics, and environmental engineering. We want more females to be attracted to the universities. The bachelor degrees are given in all the programs in Saudi Arabia but we have no engineering. Is there any plan to expand the programs in KAUST in the future to host most of the females in other fields like medical science, computer science, and other fields? Second question is most of the speakers talked about how to attract outstanding professors and outstanding students, what about professional and skillful technicians?

Answer

Dr. Al-Sultan: For the first question, I do not know about KAUST plans to expand, but even to have advanced degrees in engineering, you do not have to be an engineer yourself. Now, the experience is that many scientists choose engineering to be their advance degree. Even with the current disciplines and with the current arrangements in Saudi Arabia, I see opportunities for women with physics degrees, chemistry degrees, and mathematics degrees. Therefore, they can have advanced degrees from KAUST without expanding disciplines at KAUST. There are plenty of opportunities for women who graduate from Saudi Arabia.

Dr. Chu: I think it is important to attract technical people. Perhaps for a great research university, we do need technical supporting staff and that is extremely important. But to train technical people, that probably falls into a different type of university or college whom we may call professional schools. I think Europe probably is doing that better than in the United States.

Question

I am Amar Abdulhameed, from Saudi Aramco's Research and Development Center. I would like to thank you for the opportunity to address such a distinguished panel. The question relates to contrasting the way research and development is managed in academic institute versus managing in a research and development organization that provides services to an industrial entity. The question is open to any of the panelists to give us your insights to that comparison between the two. If the comparison allows addressing some of the discrepancies, how do you interface these two organizations as you work together to forge the necessary partnerships?

Answer

Dr. Vest: I will make an opening comment and I know there is a lot of experience on the panel. You first have to recognize that the motivations and time scales of the two organizations are different. Second, we found in our MIT experience that when we interview both the industry participants and the faculty participants after they have worked at alliances or partnerships for a while, that the number one thing they all talk about is trust. You have to establish good communication and trust between the two organizations and you have to be committed, I believe, to working together for a substantial period of time. This is the only way of melding the time scale of universities that is driven by time to a degree for students and with a more rapid time-frame for the industrial research organization. Finally, you have to have a genuine marriage of interest. The areas in which you work must be of strategic interest to the company and they simultaneously must be truly of strategic interest to the university. Otherwise, it does not work. I would like to mention some really interesting research. One of my colleagues, Richard Lester, at MIT, spent a couple of years studying, I believe, in about a dozen universities around the world that had been cited as participating in major transformation of local economies. At the end of the day, the most important role they played was actually that of a convener. It was their power to convene serious ongoing discussions among communities, industry, and academic colleagues and that everybody cited is being far more important than the details of what they had done.

Dr. Al-Sultan: I just want to comment that in the developing world, there are lots of pressures from outside the university to turn some of the universities from the educational part into training institutes and research into research and development. It is always good to be relevant and we have talked this morning about how to link your education and research to the industries. It is not good at all to overdo it. In the developing world, I see trends and calls for pressure on the university to do all what it takes to serve the industries, even if it does not preserve the university as a university. Having visited many universities in very recent years, I have seen the lines between innovation and research – applied research and basic research are more blurred now. You will find now more people in companies doing basic research, and at the same time you will find more researchers in universities doing more innovation and development. I see the time is ripe now for more interactions and mutual work in the developing countries between the university researchers and researchers in the research and development centers in the companies.

Dr. Chu: I think the important thing, just like Dr. Vest just mentioned, is a mismatch in time scales between university and industry. We have to handle that very carefully. The other part is the mismatch between mentalities of people from university and industry because usually when people in the university do research, they want to do the best to optimize them and to maximize the results to get the best results. But in industry, usually optimization becomes

more important. It's not the best results that earn you money. You have to look into the whole problem holistically and that is very important to handle these mismatches in the different areas.

Question

I am Mark Stewart. I have a comment and a question. The comment was just on tenure that comes from industry. We, as an industry, also face the challenge of attracting people and having commitment on both sides. We do not hire people to lose them in a few years. They do not generally join us to go off in a few years but there has to be a balance between that and stasis which might develop through long-term commitment. I am sure it is not beyond the wit of the academic community to devise a new model. My question is to Dr. Hegarty who spoke of the importance of community. It seems to me that KAUST by bringing people from around the world, the development of an internal community, will be enormously important in the cross fertilization from different people. Give suggestions on how that can be done and also to an extent on how the community of a university and a new university relate to the society around? Comments on that from anyone else in the panel on how to link what could become an isolated community to wider society in the country.

Answer

Dr. Hegarty: The issue of community is difficult to define. I would say for it to happen spontaneously, you do need a time-line. The last thing you probably need in KAUST is for the graduate students spending all of their time in their labs. Instead, they should be out there in the corridors talking to other students not only about their work but also about playing soccer, organizing a film society, or something else. I think KAUST does need to have this in a statement that this is important. It should encourage it and reward it. It is an organic thing which I think is not easy. Since KAUST is 90 km away from the nearest airport, it would probably have to be a self-supporting community. I think it will have particular challenges on how it interacts with local society. It would be different in downtown where you have high-density population and where it is easy to engage, but for KAUST, there is does not much else in the immediate locality. The engagement with society will be a particular challenge.

Question

My name is Ahmed Alessa, President of Al Yamama College in Riyadh. My question is you mentioned about the challenges of attracting faculty for research universities but is there any role for the research university to develop faculty instead of going outside to find good faculty and talented faculty? The

second question is to Dr. Khaled Al-Sultan. He mentioned about female-talented population in the country. Is that a sign for KFUPM to accept female students in the future?

Answer

Dr. Al-Sultan: It is ironic that I had the only university in the Kingdom which is all males, but I am quite impressed by our female student population and the door is always open for new ideas. The only reason why KFUPM was established for all males because at the time of its establishment there were not enough jobs for female engineers. The founders decided that it should be all male. But coming back to your first question, I think producing your own faculty has its own problems. I think in the United States many universities have stopped doing that. In the 1970's, although some universities do that in Japan, I think it is the other way around. Most of the universities do employ their own faculty but I am personally cautious about the self-inbreeding where you produce Ph.D's. It is okay to hire a few but not to rely heavily on employing your own graduates.

Question

My name is Mohammed Badri from Dhahran Research Center in Saudi Arabia. The question I have is for Dr. Hegarty. What was the most significant factor that helped Dublin transform to a research innovative society – is it the knowledge curiosity or economic drivers and how can other countries benefit from this experience?

Answer

Dr. Hegarty: That is a topic for a long discourse. I would say that at this stage there were two factors. One was on the government side – the flexibility and nimbleness of the government to be able to respond was vitally important. Flexibility and policy and action were vitally important. In terms of within the research community, if you go back to the bad old days in 1980's when there was no research funding around, there were no opportunities. Our academic staff found two solutions. One was the European Union and they did very well in the European Union funding because it was a matter of necessity, more than just a choice. The other was the creation of campus companies or spin-off companies. This was a way also for academic staff to find an outlet for their creativity and to find another avenue for generating resources. Both factors created a hunger within our academic community, a type of flexibility for finding solutions. As a result of that, the whole concept of spin-off of an intellectual property is a highly respected academic activity, which I think is important for the kind of society you are talking about now.

Dr. Fox: I could add to that – an addition of substantial funding for the Science Foundation of Ireland made a huge difference. The tax policies that were available to corporations that set up brands with manufacturing facilities in Ireland were a major factor. It will be interesting to see if that is withdrawn, because of the relative wealth being created in Ireland, whether it is at the same level.

Dr. Hegarty: Taxing centers are less of a factor now because all the countries are having better taxing centers than us. I think that advantage is gone. The investment in research, I hope, will continue, which is a major factor.

Question

All of the speakers in their talks emphasized the relationship between economic development and scientific research, and each of you discussed your own history. For example, in Ireland, the first Celtic Revolution was based upon graduates from teaching universities and a disciplinary workforce from very good secondary schools. Now you are engaged in a second revolution based upon transforming your universities into very quick active research universities. From Dr. Chu we heard about Hong Kong, a financially important city in the world wanting to become an intellectual center based upon new knowledge of the new university and also helping China over the next decades develop strong technology and a new knowledge-based country. In San Diego, somehow over a period of one generation, it attracted perhaps one of the best faculties in the country and their influence led to the economic transition of San Diego from a defense-based city into a biotech center and communications industry center. We have learned a great deal about KAUST – what its aspirations are, how it is going to achieve them, and how it is going to start off initially as a teaching and research university. But KAUST is in a country with a single major industry, with rich resources and beautifully managed. It wants to diversify, it wants spin-off, and it wants knowledge-based industries to develop overtime. Over what period of time do you think that can occur? Is it measured in decades, is it measured in generation, or is it a gradual transition – how it will happen?

Answer

Dr. Chu: I would like to say in decades. I feel that the people involved in the establishment of this great university should be patient; otherwise, the people will be disappointed.

Dr. Fox: It is always very difficult, but the data that I showed about San Diego did take 20 to 30 years, even with optimal conditions and the gradual shifting from one industry to another. There is more severe dislocation here and it will require patience. I think the focus that has been suggested in the areas that the academic leaders for KAUST have described are exactly the right way to go about

this. We have enough exploration of different areas to be able to exploit those from which discovery emerges.

Dr. Al-Sultan: I would like just to emphasize that we have talked about the research university being a catalyst for doing all of this, but it needs the right environment. In Saudi Arabia we have many initiatives that are unseen to people from outside of Saudi Arabia. I do hope that all of these initiatives will help KAUST expedite the process but still I think you need probably years, probably a decade for this.

Dr. Vest: It is a tough question and I would like to give a slightly hard-edged answer. Each of the three countries or regions you referred to face a severe crisis at the time in which this transformation began. I know them all and I will take time to tell you. There is a sense in which there is not, at the moment, an equivalent crisis here that may drive that transformation. I suspect that what is required is still going to be fear that the time in which an economy based on a single primary element may disappear for whatever reason. I hope that our colleagues will keep in mind that as they build for the future, what they really have to do is address the time. That monolith may no longer be able to drive the economy but that fear and crisis played a role in each of these major transformations.

Question

I am Aban Abdullah from University of Putra Malaysia. I had good fortune of being associated with this university from the very beginning when we formed the project management team. After listening to the presentations, I noticed that we do have the right ingredients to make KAUST into a great university. We have endowment, a generous endowment. We have the political will, we have the opportunity to get the right academics, and we have the opportunity to get the right facilities. But I think what we do not have is time. We have been constantly reminded that we would like to have this university become a top university in the shortest possible time. If the other universities can have 150 years or 100 years to become a top university and KAUST needs to be a top university in the shortest possible time, my questions to the panel members are do you have any tips on how to fast-track the process to make KAUST into a top university in the shortest time possible, how to speed up the process, and what are the catalysts for speeding up the reaction?

Answer

Dr. Hegarty: I do not think you can just make it happen. I think these things do take time. Perhaps what is different here from the other cases is that you have

money. But that is not an issue as far as I understand and your challenge is to get people. For many of us, the challenge was the opposite – getting people was less of an issue, but getting the money was a big problem. Maybe this is unique. Maybe it is possible that if you have the resources available from the beginning, you can actually force the march. I am not sure if that has been experienced elsewhere, but certainly I will be watching that.

Dr. Chu: I just want to share our experience with you. Certainly, Hong Kong University of Science and Technology is not MIT, not UCSD, not Harvard, and not Cornell. But in a very short period of time we did manage to move up quite rapidly. First, we did get sufficient support at the beginning by the government. Secondly, we laid down a very rigorous, fair, and transparent system for the recruitment of faculty members, and then we are located in a beautiful place and that makes everything easy. If we had the financial support like KAUST has, I think we could have accomplished much more. I still believe that KAUST can achieve its distinction in a very short time compared with the rest of the world's institutions.

Question

Good morning everybody and I welcome all the speakers – national and international. I would like to say with no hesitations that we have suffered decades of sluggish and, if not crippled, handicapped high education. It was only yesterday that we opened a wide gate for a real high education. I want to extend my congratulations to everybody in my country. My question is specifically to Dr. Khaled Al-Sultan. You spoke about the uniqueness of the Kingdom. This is the world you spoke about and that the Kingdom would be able to attract scientists and researchers from the Middle East and Muslim countries. As far as I know, you will open the university in the beginning of 2009. I do not know how we are so confident that we are still a unique country and that we will be able to attract talented and unique people for this unique university. We know that even Middle Eastern and other countries are overwhelmingly developed industrially, economically, financially, and educationally. In the very near future, I do not think it will be that easy as it was before to attract the quality of brains that we need. Let me give you an example, only a few months ago I was in a committee for contracting nurses and technicians. The country where we used to receive thousands a day, we were not able to have the quality we wanted. We are speaking about a university which is our dream. Do we have another alternative? Do we have another realistic strategy on policy to overcome this problem if it happens? Because we dream a lot, we do not want to continue dreaming without reality being seen.

Answer

Dr. Al-Sultan: First of all, I do not want to speak on behalf of KAUST. I know the KAUST is putting a lot of effort and a very attractive package for recruiting

faculty. They will use their strategic alliances as well as their scholarship program to attract talented faculty. Let me tell you our experience at King Fahd University of Petroleum and Minerals (KFUPM). We have experienced the difficulty of attracting people who are well established, especially those who are in the middle of their career. But we have had wonderful experiences attracting very promising fresh graduates, especially people from the Middle East. Now we have in our faculty people who can get jobs in any top school in the United States but they decided to stay at KFUPM because they want to stay close to their family and they want to be in a Middle Eastern country. One of the important factors is that you do not rely only on hiring established faculty in their mid-career. You combine that with hiring very promising fresh graduates who will in a few years become leaders in their own field. But that is only one factor. I do not want to say that the hope in Saudi Arabia and opportunity comes from only that. That is only one out of many, and definitely we have seen that in KFUPM. I see no reason why it should not be witnessed at KAUST.

Question

I'm Dr. Mona Al-Sheikh, assistant vice dean for the Parallel Program. King Faisal University has witnessed in the last five years the birth of a new college for medicine which combines problem-based learning and traditional learning in the same package. Our graduates will be ready in the next two years and the indicators are very promising. My comment and question is for Dr. Vest. I enjoyed your talk to the maximum, and as an educator I could not agree more about the empowering effect of KAUST on institutes in Saudi Arabia and the region as a whole. My concern is what will be the negative effects on other institutes in the area? I mean if the cream of Saudi Arabia's university faculty and students trickle to KAUST because they can pay more, they can get better housing or better facilities, what will happen to our institutes which we are trying very hard to bring up?

Answer

Dr. Vest: I think this is a very good and obviously heart-felt question. I can reflect only on things I have observed in the past, and that is I believe that excellence begets excellence. Let me give a couple of examples. At MIT, and people in the audience are very familiar with this, we started something called the Whitehead Institute and it was relatively well endowed, had more flexibility, freedom, and resources. Everybody worried that we will create first- and second-class citizens within our own university community. The fact is it pulled everything up. If you look around the Boston area that I know so well academically, people would say Harvard. Harvard has a huge endowment and they have a 300-year tradition and reputation, why should we bother? The fact is that around that community, in due course, grew MIT, Boston University, and Boston College – a new Massachusetts.

There is a way in which excellence begets excellence. It may take a little patience, but I would hope that you keep making your cases in other institutions. In due course, the interchange will cause all ships to rise. This is something I would be optimistic about.

Dr. Al-Sultan: If you say you can or you cannot, you are right. For my colleagues in other universities, if you think KAUST is an opportunity or is a threat, you are right. It depends on the attitude. I tend to look at it as an opportunity. Definitely in the very short-term, it might be attracting more faculty and students. But I think this is a huge country, and KAUST by the scale of the numbers is small, about 2000 students and about less than 1000 faculty. Definitely it will have, in my opinion, an effect that will improve education and research in all other Saudi universities.



Dr. Fawwaz T. Ulaby

*Past Vice President for Research
R. Jamison and Betty Williams Professor
of Electrical Engineering and Computer Science
University of Michigan
Ann Arbor, Michigan, USA*

The afternoon session will cover the economic and scientific aspects, and I would like to introduce our moderator, Dr. Fawwaz T. Ulaby. Dr. Ulaby is the R. Jamison and Betty Williams Professor of Electrical Engineering and Computer Science at the University of Michigan where he recently completed a seven-year term as vice president for research. He is a member of the National Academy of Engineering. He is editor in-chief of the *Proceedings of IEEE* and serves on several national scientific boards and commissions.

After joining the University of Michigan in 1984, Dr. Ulaby directed interdisciplinary, NASA-funded projects aimed at the development of high-resolution, satellite-radar sensors for mapping the earth's terrestrial environment. He also served as the founding director of the NASA-funded Center for Space Terahertz Technology whose research was aimed at the development of microelectronic devices and circuits that operate at wave-lengths intermediate between the infrared and the microwave regions of the electromagnetic spectrum. Over his academic career, he has supervised more than one hundred talented graduate students.

Dr. Ulaby attended the American University of Beirut from which he received a B.S. degree in physics in 1964. He later received a Ph.D. in electrical engineering from the University of Texas, at Austin, in 1968. In between, he worked for Boeing Company for one year in 1966.

Afternoon Session

**The Role of the Research University in the 21st Century:
Scientific and Economic Aspects**

Dr. Fawwaz T. Ulaby
*Past Vice President for Research
R. Jamison and Betty Williams Professor
of Electrical Engineering and Computer Science
University of Michigan
Ann Arbor, Michigan, USA*

Distinguished guests, ladies and gentlemen, I welcome you to the afternoon session of the symposium in which our discussion will focus on science, technology, and

University of Michigan

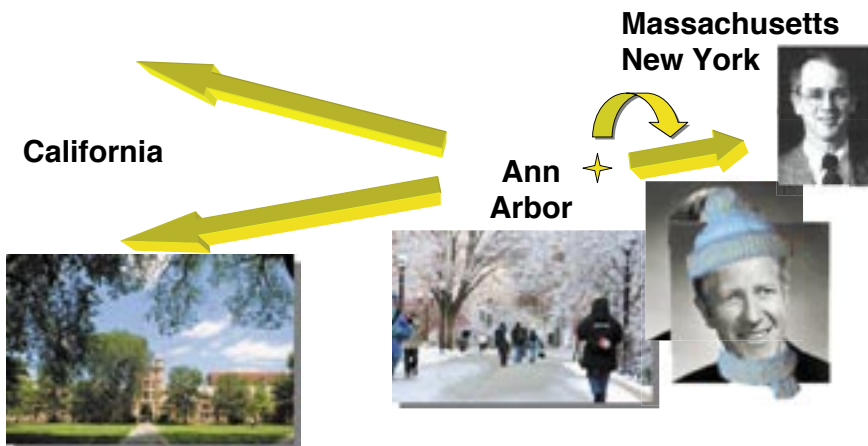


Figure 1. Movement of Michigan faculty.

economic development. I too would like to add my salute to KAUST and the bold vision it embodies. Sponsoring the symposium is a tribute to the academic architects of KAUST whose progressive thinking led them to posing the question – what should define the research university of the 21st century?

As Mr. Al-Khowaiter mentioned when he introduced me, I come to you from Ann Arbor, Michigan. So permit me a couple of minutes of your time to introduce you to Ann Arbor. For about nine months of the year, Ann Arbor is a wonderful place to live; people enjoy its resort-like climate and engage in its many cultural and sports activities. But come winter, well, that's a different story! Occasionally, some of our less-persevering faculty may decide to move to a milder climate and most, as you might expect, opt for sunny California, although a few may decide to go to the East Coast (Figure 1).

An example of the latter group is our keynote speaker, Dr. Vest. In 1990, he left Ann Arbor for Boston, Massachusetts, not that the weather in Massachusetts is much of an improvement over that of Ann Arbor, but admittedly, going there to assume the presidency of MIT is partially understandable. Now, it has been said that every rule has to have an exception to prove it, so how does one prove the theory of why people migrate away from Ann Arbor? You prove it by moving from Ann Arbor to an even colder place, like Ithaca, New York! And who should provide that exception, none other than the moderator of our morning session, Dr. Frank Rhodes. He and his wife Rose deserted us 30 years ago to assume the presidency of Cornell University. We still love and miss the Rhodes and the Vests, and Ann Arbor will always be home for both of them.

Interconnectedness of Science and Technology

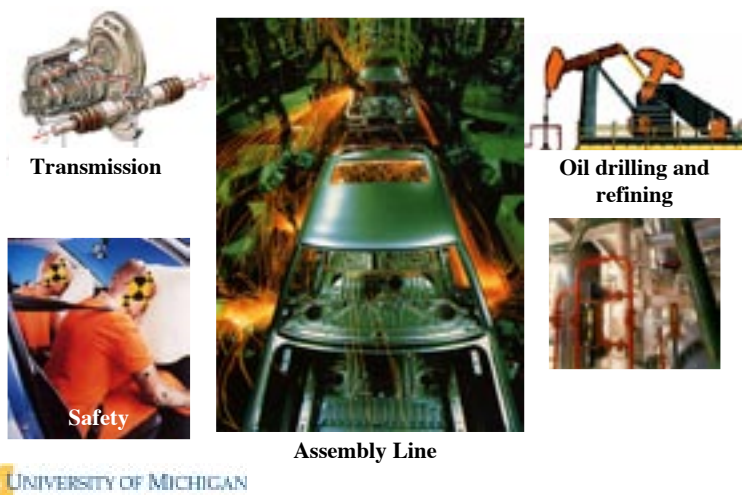


Figure 2. Interconnection of Science and Technology.

Eras of Modern Science and Technology

The Age of Physics

~1900-1950:

1897 J.J. Thompson discovers the **electron**

1900 Max Planck introduces the **Quantum Concept**

1905 Einstein $E = mc^2$

1913 Bohr's model of the **atom**

1932 Chadwick discovers the **neutron**

1942 Fermi - First man-made **nuclear chain reaction**


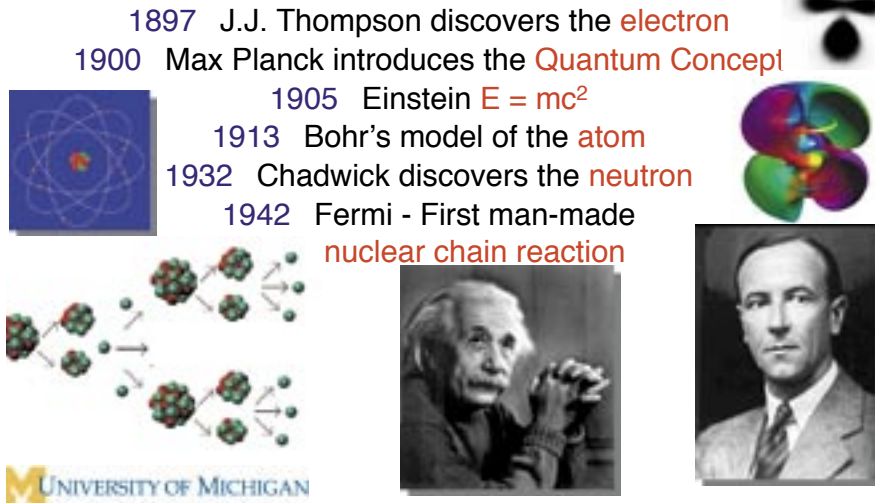


Figure 3. The Age of Physics 1900-1950.

Now that you know all about the history of Ann Arbor, it is time that we start with the real purpose of this session. Our panelists have been asked to share with you their vision of the future as it pertains to science, technology, and economic development. And by way of a backdrop, I will offer one man's perspective on the past 100 years. We all know that many fields of science and engineering are highly interconnected and that every product is realized by its constituent technologies (Figure 2), but while we understand that, and at the risk of oversimplification, please permit me to answer the following question – what single field of science or engineering stands out among all others, in terms of the scale of the transformation it underwent during the first half of the 20th century and in terms of its impact on other fields of science and technology? I submit to you that the first half of the 20th century was the **Age of Physics**.

Consider the following chronology (Figure 3). Around the turn of the century, J. J. Thomson discovered the electron and measured its charge to mass ratio. Shortly thereafter, Max Planck introduced the quantum concept when trying to solve the blackbody radiation problem and that led Einstein to establish the connection between energy and mass. People knew for a long time that there had to be a connection between mass and energy, but no one realized that the connection is the velocity of light, a quantity that has zero mass. It is certainly one of the most elegant attributes of nature. Bohr came along and introduced the model of the atom we use today. Over the next 20 years, a search ensued to prove that the neutron indeed exists, and Chadwick provided that. Eventually, those plus all of the other

Eras of Modern Science and Technology

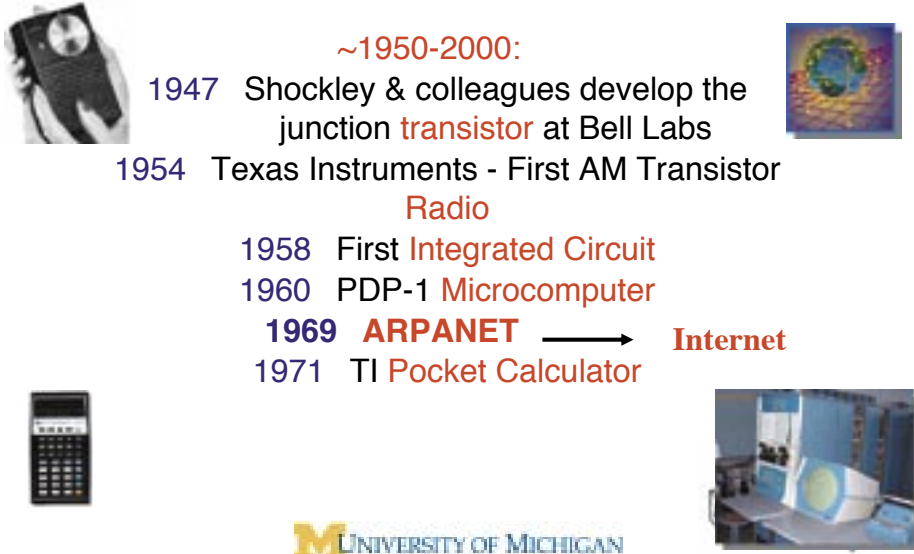
The Age of Electronics

Figure 4. The Age of Electronics 1950–2000.

discoveries of that period led to the major climax of that half of the century in the form of the first man-made demonstration of nuclear chain reaction by Fermi. In a nutshell, the quantum physics of the first half of the century introduced a new paradigm and a new way of thinking – thinking in statistical and probabilistic terms and regarding elementary particles as wave packets of energy, very different from the deterministic viewpoint that had existed previously.

So the first fifty years of the 20th century was unquestionably the **Age of Physics**. What about the next fifty years? I submit to you that the quantum model of the atom led to the most transformative era in the history of civilization – 1950 to 2000 was the age of electronics (Figure 4). In 1947, because of the new understanding that physics had introduced, it was possible to conceive and demonstrate the capabilities of the first junction transistor.

Not surprisingly, its developers, Shockley and his colleagues, were awarded the Nobel Prize in Physics in 1956. Within a few years after its invention, the transistor led to the development of many new products, including the first AM transistor radio in 1954. In some ways, the portable transistor radio represented the first step in the transition towards miniaturization and low power consumption. The transistor evolved into the single most impactful development in the world of electronics – the integrated circuit (IC). Using germanium as his basic building material, Jack Kilby at Texas Instruments demonstrated in 1958 a working model of an IC that included multiple transistors and other circuit elements, all integrated

onto a single chip. For this and other later discoveries, Jack Kilby was awarded the Nobel Prize in Physics in 2000. Within three months of Kilby's demonstration of the IC, Robert Noyce, who was at Fairchild at the time, developed and demonstrated his own IC using silicon instead of germanium. Shortly thereafter, Noyce joined Gordon Moore to form Intel, and we all know what Intel does today.

By 1960, we had computers that could operate in a laboratory setting. The PDP-1, and later on the PDP-11, became a must for any self-respecting researcher in science and engineering. I remember using a PDP-11 when I was a graduate student. The development of a global communication network allowed us to start thinking on a global scale. The ARPANET that was created in 1969 eventually evolved into the Internet that we all use today. Personal computing started with the introduction of the first IC-based hand-held calculator in 1971, to be followed shortly thereafter by the first Apple computer. At the time, Apple's thinking was that only a small segment of society would use the Apple-1 computer, so they introduced it in kit form to be assembled by the user. The response to the Apple-1 was so overwhelming that the company shifted to selling fully assembled units on a much larger scale.

In the early 1980's, we saw the introduction of Microsoft and the MS operating system, and by 1981, IBM introduced its own PC to compete with Apple. Moving forward to 1989, which was only 18 years ago, we saw the exponential expansion of the worldwide web that we have today. By 1995, the cell phone became ubiquitous in everybody's hand, and by 2002 it could support both video and Internet. My last one for that part of the century is the wireless LED. The wireless LED, also known as the blue LED or the white LED, will revolutionize the construction business in the future. Not only is it fifty percent more efficient in comparison with current illumination



Figure 5. Age of Electronics: society impact.

systems; but it can be built within walls, ceilings, etc.; can be programmed; and can be supplied with energy wirelessly. It is going to change how we design and build our living environment very dramatically.

In conclusion, the age of electronics provided us the means to go into space, provided new means of transportation systems, and provided manufacturing in ways that we never could dream of before (Figure 5). It improved food-production systems,

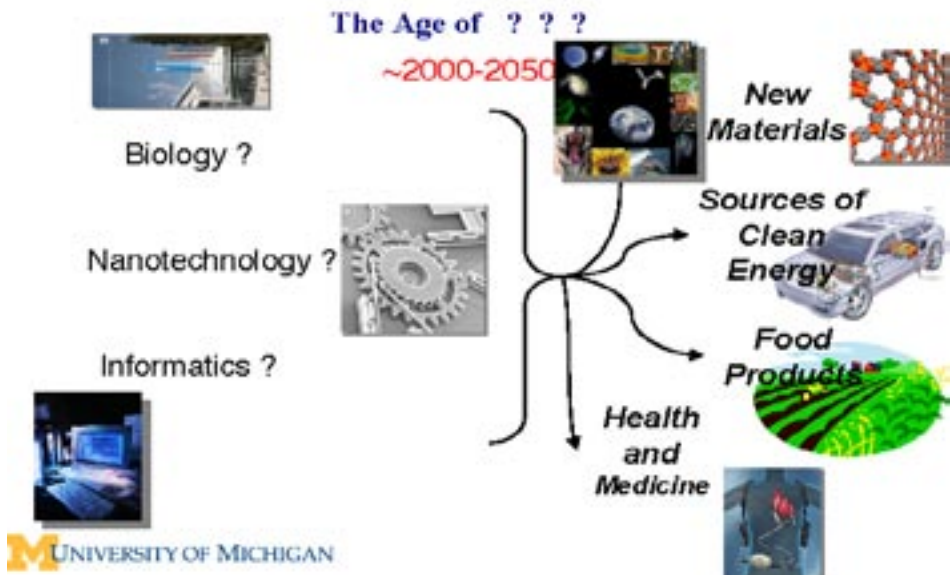


Figure 6. What will the future bring?

introduced a new world of entertainment, and revolutionized medical diagnosis.

Moving forward, what will we call the era of the next fifty years (Figure 6)? Will it be the age of biology? Nanotechnology? Or perhaps informatics? Those are the buzz words people talk about. It is probably going to be the combination of those and many others, leading to new kinds of materials, to new sources of clean energy, to genetically engineered food products, and to improvements in health and medicine.

That leads me to the last topic – the questions for the panelists to address. (Figure 7).

Looking into your crystal ball...

- What are the future challenges and opportunities in science discovery and technology innovation? How will they define the character of the Research University of the 21st Century?
- How should investment in basic sciences research be balanced against support of applied research and development?
- How should investment in basic sciences research be balanced against support of applied research and development?
- The dot.com economy has evolved in part from a tenuous partnership between the venture capital community and the faculty entrepreneur. Do you foresee new economic models emerging in the future, and what will be the role of the Research University of the 21st Century?
What advice would you offer the Founding President of KAUST and his/her administration?
 - On Academic Culture
 - On The Ideal Graduate of KAUST
 - On the Relationship of KAUST to Industry

Figure 7. Questions for the panelists.

We have asked the panelists to consider four questions and to respond to any one or more of them.

Question 1: Looking into your crystal ball, what are the future challenges and opportunities in science discovery and technology innovation and how will they define the character of the research university of the 21st century?

Question 2: How should investment in basic science research be balanced against support for applied research and development?

Question 3: The dotcom economy has evolved in part from a tenuous partnership between the venture-capital community and the faculty entrepreneur. Do you foresee this model continuing into the future or will new economic models emerge over the next decade, and what will the role of the research university of the 21st century be in this regard?

Question 4: What advice will you offer the Founding President of KAUST and his or her administration?



Dr. Karen A. Holbrook
*Past President, Ohio State University
Columbus, Ohio, USA*

Our first panelist is Dr. Karen A. Holbrook. She is the immediate past president of Ohio State University. Before that, she had assumed a number of leadership positions at several different institutions, and she is a biochemist and a zoologist by profession.

Dr. Holbrook became the thirteenth president of Ohio State University on October 1, 2002. Since she took office, Dr. Holbrook has made cutting-edge research a priority and an integral part of the educational process at all levels of the university. As a result, Ohio State's sponsored research funding has topped \$652 million, an all-time high. Ohio State now ranks ninth among public universities in research expenditures.

Dr. Holbrook came to Columbus from the University of Georgia, where she served as senior vice president for Academic Affairs and as provost. She was professor of cell biology and adjunct professor of anatomy and cell biology and medicine at the Medical College of Georgia. Before that, Dr. Holbrook served at the University of Florida, at Gainesville, as vice president for research and dean of the Graduate School, as well as professor of anatomy and cell biology and medicine (dermatology). She spent the majority of her academic career as a professor of biological structure and medicine at the University of Washington, School of Medicine, where she gained a reputation for expertise in human fetal skin development and genetic skin disease and was an NIH merit awardee. She also served as associate dean for Scientific Affairs.

Dr. Holbrook earned her B.S. and M.S. degrees in zoology at the University of Wisconsin, in Madison, and a Ph.D. in biological structure from the University of Washington, School of Medicine, where she pursued postdoctoral training in the Department of Medicine, Division of Dermatology.

Dr. Holbrook has done an outstanding job at Ohio State and I would like to read to you a short quote describing her tenure there, "She has been a trailblazer at Ohio State, and for those who may not be familiar with the term trailblazer, she charted new paths and new directions. We have had very successful five years under Dr. Holbrook and the university is better by far because of it."

The Role of the Research University in the 21st Century: Scientific and Economic Aspects

Dr. Karen A. Holbrook
Past President, Ohio State University
Columbus, Ohio, USA

I am deeply honored to be invited to participate in this landmark symposium and am especially privileged to be involved in the development of this great university. I offer my profound congratulations to His Majesty, King Abdullah, Custodian of the Two Holy Mosques, whose vision for KAUST is unparalleled.

The questions posed to this panel are being asked in research universities all over the world, but KAUST is in an enviable position as they answer them because of its unique situation of:

- Financial stability and independence
- Manageable size
- Strategic prioritization established before faculty are recruited
- Establishment within the knowledge economy as an international center for education and research "Uncommon freedom" for faculty investigation
- Lofty and noble goals – the outcome of which will positively impact the social, economic, and industrial development in Saudi Arabia and the rest of the world
- Unencumbered by a past, KAUST has the opportunity to create the right template for success for students, faculty, the University, and the Kingdom – an opportunity and a challenge
- Differentiation in the competitive market

Question 1: What are the future challenges and opportunities in scientific discovery and technology innovation and how they will define the character of the research university in the 21st century?

Let me begin by side-stepping the question and offering what I believe is a fundamental theme and element for the future of KAUST.

Today, we know that "the world is dramatically being reshaped by scientific and technological innovations, global interdependence, cross-cultural encounters and changes in the balance of economic and political power."¹ Innovation is a key word in this question and in the quote, and is a word we have heard repeatedly. Innovation is KAUST's very nature and its core design for success. Innovation has been defined by

the Council on Competitiveness as the "intersection between imagination, insight, ingenuity, invention and impact" – the five "I"s. Innovation can come from anyone, anywhere, and can be represented in a product, a process, service, or a strategy. Innovation is open, collaborative, multidisciplinary, demand-driven, global, and involves an element of risk.²

According to the Council, "innovation will be the single-most important factor in determining America's success through the 21st century. ... For the past 25 years, we have optimized our organizations for efficiency and quality. Over the next quarter century, we must optimize our entire society for innovation" (Innovate America).

The Council has recommended an innovation policy that will drive growth in productivity and promote high standards of living and success in global markets. The elements of this policy take into account:

- Growing a science and engineering workforce and workforce training
- Entrepreneurship
- Healthcare
- Tech transfer
- K-12 and higher education
- Business-university collaboration
- Intellectual property
- Regional economic development
- Manufacturing

Many aspects of innovation policies are universal, reflecting thinking that must occur at the national and global levels. Innovation policy challenges nations to stimulate a greater intensity of R&D, encourage public-private partnerships, develop clusters of innovation and larger more unified venture markets, and to promote global collaboration.³ KAUST is targeted to meet these challenges.

The Council has also established an innovation agenda that could also be an agenda for the entrepreneurial university and clearly is in sync with KAUST's goals:

- Educate the next generation of innovators and prepare students to become citizens of "an interconnected and unequal world" (Howland)
- Deepen science and engineering
- Explore knowledge intersections where the greatest breakthroughs occur
- Equip workers for change
- Support collaboration
- Energize entrepreneurship
- Reward long-term strategy and investments and couple with near-term strategies to make an immediate difference
- Build world-class infrastructure
- Invest in frontier research
- Attract global talent
- Create high-wage jobs

Innovation and the Present

Innovation can offer new insight into the global problems universities are pursuing today:

- Emerging infectious diseases HIV/AIDS and other pandemics
- Health disparities
- Renewable energy
- Environmental sustainability
 - Global warming
 - Clean and safe water supplies
 - Air quality
 - Pollution
 - Depletion of natural resources
 - Threatened loss of endangered species
- Poverty
- Hunger
- Food safety
- Nuclear proliferation
- Terrorism, geopolitical conflicts and, conversely, peace
- Transportation

Innovation and the Future

Innovation is essential to solve the problems of the future. According to Deborah Wince-Smith, CEO of the Council on Competitiveness, "Innovation has always been the way people solved great challenges facing society. Innovation will lead to the solution of problems that do not even exist yet, to the opening of new vistas of undreamt opportunity for ourselves and future generations."

Looking back over the past twenty years, we can see clearly how difficult it is to predict the future as not only the nature of change but also the rate of change that have occurred in science and technology have been almost unfathomable. But this fact gives us the confidence to be bold in our predictions because almost anything we might think of as outrageous is probably not impossible! The fact that we are here in the Kingdom – celebrating the future of this bold and creative, global science and technology university, a university focused on addressing issues of concern to Saudi Arabia and also the world – discussing this topic, is certainly testimony to the accuracy of this statement.

Looking Forward

1. Technology will continue to drive research as a global enterprise. Information technology and telecommunications provide for a growing economy and a safe and secure society. Technology offers flexible learning environments for students of all generations. Global information and

technology are commodities in today's world.

2. Universities will develop and participate in a global agenda for innovation and research and in doing so will work to transform themselves into global universities that play an important role in preparing students and scholars to become global citizens and leaders in their own countries and perhaps in other countries as well.
3. Universities will collaborate by clicks and bricks. India, Qatar, Abu Dhabi, Malaysia and Singapore – all across the globe universities are involving partners of other corners of the world in their own ventures.
4. Universities will also compete. Our challenge is to determine how to work so that collaboration trumps competition.
5. Research must concern more than science and technology. It will also engage knowledge of culture, language, ethics, economics, and engagement. According to Grant H. Cornwell, "the problems our student must engage as they make their way in the world are an intertextual tangle of scientific, social-scientific, and humanistic issues."⁴
6. We will need to scan the world for new ideas and be nimble enough to invest in them. The Not-Invented-Here syndrome will not succeed. KAUST is an example of what the world should be doing – picking the best from everywhere and bringing them together to learn and to innovate without geographic boundaries and to be "open and receptive to ideas and innovations generated in places other than those with which they are familiar."⁵
7. Whatever the challenges in research, the new system of wealth will favor those with judgment, intuition, creativity, and insight, said Deborah Wince-Smith; "The conceptual economy will favor nations that reach globally for markets, and those who embrace different cultures and absorb their diversity of ideas into the innovation process."

Question 2: What should be the balance between the investment in basic science research and the support for applied research and development?

This issue has been a topic for many years, but it is perhaps less significant today in universities in the United States in as much as research funding available to faculty members is diversified and supports both types of research.

Federal R&D funding is typically an investment in frontier research. More recently, a class of grants, such as the NIH Director's Pioneer Awards and New Innovator Awards, was offered competitively to fund unconventional ideas and to encourage

young investigators to be bold in proposing novel projects. Dr. Zerhouni, NIH Director, believes that "the conceptual and technological breakthroughs that are likely to emerge from their highly innovative approaches to major research challenges could speed progress toward important medical advances." Other research grants from the federal government require universities to partner with industry and the transfer of technology is expected.

Industry funds faculty and researchers, typically in targeted areas where promising preliminary work has suggested a breakthrough in a concept or product to bring to market. Applied research is now central to universities' role in economic development. Universities have created mechanisms through technology transfer offices, business incubators, and research and development parks – some of which include private sector companies as partners – to promote the transfer of research findings as well as commercialization of intellectual property and development of start-up companies. How robust these mechanisms are is determined by the culture of the university. Some are more entrepreneurial than others and have had technology transfer activities in place for many years. Many faculty like to see that their work has relevance and are anxious to protect and license their discoveries to be commercialized, or even to start up their own companies. Other faculty still needs to buy into the value of this activity.

Countries, especially those in the position of developing research programs anew, must wrestle with the issue of balance for the first time. Their concern, however, is often focused on how best to invest scarce resources for optimal return.

Finally, as teaching and research are inseparable, basic research and applied research are also coupled for optimum benefit. There needs to be a strong foundation of basic research upon which applied research can benefit. Basic research is the "seed corn" that continues to produce the innovations that lead to success in the market place. Many of the most innovative industries were built upon research that had no targeted application at the time it was carried out – e.g., quantum mechanics spawned semiconductors and IT. By creating an environment where innovation and entrepreneurship are valued, it is inevitable that students and faculty will find a practical outcome to their efforts.

The KAUST plan provides an ideal opportunity to exploit the synergy between the basic research carried out by investigators involved in the Global Research Program and the partnership they can develop with the applied research on the KAUST campus. This is a powerful linkage to stimulate cooperative investigation leading to the handoff of results to those who can take it to market. To quote the late Ernest L. Boyer, the 7th president of the Carnegie Foundation for the Advancement of Teaching, this is an ideal situation to bring "thought to action [and] theory to practice."

Question 3: The dot.com economy of the past 20 years evolved in part out of a tenuous partnership between the venture capital community and the academic entrepreneur. What new economic models do you see emerging in the future and will the research university of the 21st century have a role in them?

1. Funding models based on interaction and collaboration – both public and private investment for public gain.
2. Entrepreneurship as a theme for universities.
3. Finding champions to support incubator facilities and a venture capital environment for development of technologies:
 - TechColumbus
 - Tech Transfer Offices appropriately funded and directed
 - Well thought-out reward system for people who are engaged in these activities
 - Ireland has Competency Centers created by IDA, EI, and SFI; Scotland has Intermediary Technology Centers for business and university partnerships to become established
 - Opportunities to bring together business with university faculty and students and a source of funding
 - Statewide Initiatives:
 - Third Frontier in Ohio
 - Georgia Research Alliance
 - Michigan Life Sciences Corridor
 - Proposition 301 in Arizona
 - Partnerships in big ventures
 - Federal laboratories in the states and often associated with universities to develop applied research for government service and priorities

Question 4: What advice do you offer the Founding President of KAUST and his/her administration?

1. Own only what is your primary agenda. KAUST is a vast project and others are responsible for parts of it that are not within your purview.
2. Understand the culture of the environment in which you are working – this is true for every new administrator. There is a very special relationship between the Royal Family and KAUST – trust, understanding and connection.
3. Engage the faculty – they establish the quality.
4. Engage business for advice and insight.

5. Consider how to build a Saudi Arabian pipeline of students who are well prepared for success in KAUST and the STEM disciplines.
6. Strive for openness, transparency – easy access to information.
7. Couple science and technology training with entrepreneurship, creativity, innovation, leadership and ethics, and social responsibility.
8. Be nimble and flexible – leave space for the wild card.
9. Identify possible barriers to the success of KAUST and devise solutions to overcome them before you are up against them.
10. Become part of the network of Saudi Arabian universities and grow roots around the world. Is there a consortium of major international universities? The Prime Minister of Singapore, Mr. Lee Hsein Loong, was the guest of honor at the closing dinner of the AAU-APRU President's Roundtable in Singapore. He remarked that "Universities are key institutions that help societies to prepare for change, but they themselves are subject to the same powerful pressures to adapt. They must learn from one another and change with the times to better prepare the young for a different future."

A quote I often cite because of its relevance in today's world, "peace and prosperity in the 21st century depend upon increasing the capability of people to think and work on a global and intercultural basis. As technology opens borders, international education opens minds" (*IIE Annual Report*).

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Dr. Wolfgang A. Herrmann
President, Technical University of Munich
Munich, Germany

Dr. Wolfgang A. Herrmann is president of the Technical University of Munich (TUM), where he has been president for the past 12 years. Dr. Herrmann has served as president of TUM since 1995, having been re-elected in 1999, 2005, and 2007.

Dr. Herrmann earned his Ph.D. in chemistry, in 1973, in the area of metal organic chemistry. His scientific work has produced more than 720 original publications, numerous review articles, and book contributions. More than 150 theses have been developed under his guidance. He is the owner of numerous honor doctorates from universities in France, Hungary, Romania, the United States, Portugal, Germany, and China. He is also the owner of numerous national and international honors; among them the chemistry prize from the Academy of Sciences at Goettingen in 1979, the Gottfried William Leibniz prize of the German Research Council in 1986, the Alexander Humboldt prize in 1989, the Max-Planck research prize in 1991, the Italian Chemical Society's medal in 1994, the William Wedge prize in 1995, and many more.

His comprehensive reform work at TUM has earned TUM, in the Focus Ranking of German universities, the first ranking since 2004. For his university reform work at TUM, Dr. Herrmann received the Bavarian Medal in 2005.

I contacted a former Ph.D. recipient of TUM and asked him about Dr. Herrmann and this is what he said, "Under President Herrmann's leadership, TUM has continued to excel in science and technology and to expand its international partnerships including MIT, Stanford, Cornell, Tokyo Institute of Technology, and the National University of Singapore." TUM is truly an international university.

The Role of the Research University in the 21st Century: Scientific and Economic Aspects

Dr. Wolfgang A. Herrmann
President, Technical University of Munich
Munich, Germany

Mr. Chairman, ladies and gentleman, I am honored to extend my congratulations to the Custodian of the Two Holy Mosques, His Highness King Abdullah.

I am truly fascinated on the unique concept of this research university. This university will concentrate the world's attention to a geographical area of our planet which undeservedly has been underestimated for a long time. This will change now with this university in science and technology as well. My university, in the year 1868, was also established by a king, the King of Bavaria, at a time when it became clear that we had to change from a merely agricultural and mercantile country to take up new inventions in science and technology.

Presently, the Technical University of Munich (TUM) has three campuses. The Central Science and Technology Campus in Garching (Figure 1), north of Munich, was established 50 years ago. It is of extreme importance that a comprehensive campus where scientists working on different disciplines, who have developed different ways of thinking and different ways of doing research, be close to one another and be able to easily communicate on a daily basis. In the state of Bavaria, we are a public university and we have made investments of more than one billion euros in the past ten years in this particular campus.



Figure 1. Technical University of Munich, Garching campus.

Our Faculty of Mechanical Engineering, located on this campus, develops strong activities in mechatronics, automotive, and aerospace research. One of the symbols

of this campus is the egg-shaped building of the Neutron Research Reactor (built 50 years ago), which has just been replaced by the most modern neutron reactor in the world and went into operation three years ago (Figure 2). This campus will also house in the near future our new Institute for Advanced Study, which models after the famous institute that began in the United States, in 1930, at Princeton, to give outstanding research possibilities to the most gifted and experienced scientists and to establish scientific schools with a high degree of freedom.



Figure 2. TUM's Neutron Research Reactor.

We believe that the freedom in science and research is the most efficient contribution to the progress in science and technology. The 21st-century university certainly has to be international. It has to undertake international alliances. It has to be transdisciplinary. Of course, it depends on having strong key competencies in the various disciplines. Otherwise, trans-disciplinarity makes no sense.

A present-day university has to be entrepreneurial. In heading a public university, we have to make our own decisions, and we have to have independent governance. Creativity has to be supported at all levels. Besides having excellent professors, excellent graduate students are of equal importance. They only can unfold their fascination if you support their creativity in science and research. Since too much bureaucracy is around in the world, the research university especially has to be as unbureaucratic as possible.

Let me make a further remark – one has to appreciate the traditions but also one has to be ready for change. A university that was started in 1868, like TUM, in a completely different society has to go through many changes and amendments. But I am more convinced than ever that a top university has to have its home roots, has to know where it comes from historically, and has to have an appreciation for the

religion of the people, for example, those who carry these institutions. Only if you have roots, you can be successful out in the world.

It is not necessary that you have to be comprehensive regarding the whole spectrum of natural and engineering sciences. For historical reasons, we are comprehensive as a technical university. Actually, the other technical university in Europe, which is as comprehensive, is the Imperial College in London. We have four sectors: science; engineering; medicine including university hospitals; and life sciences including plant and animal science, ecological science, and nutrition science and food technologies. The twelve TUM departments have their key competencies and are able to collaborate within the universities and with outside partners. From these internal alliances, we establish alliances with top universities in the world (Figure 3).

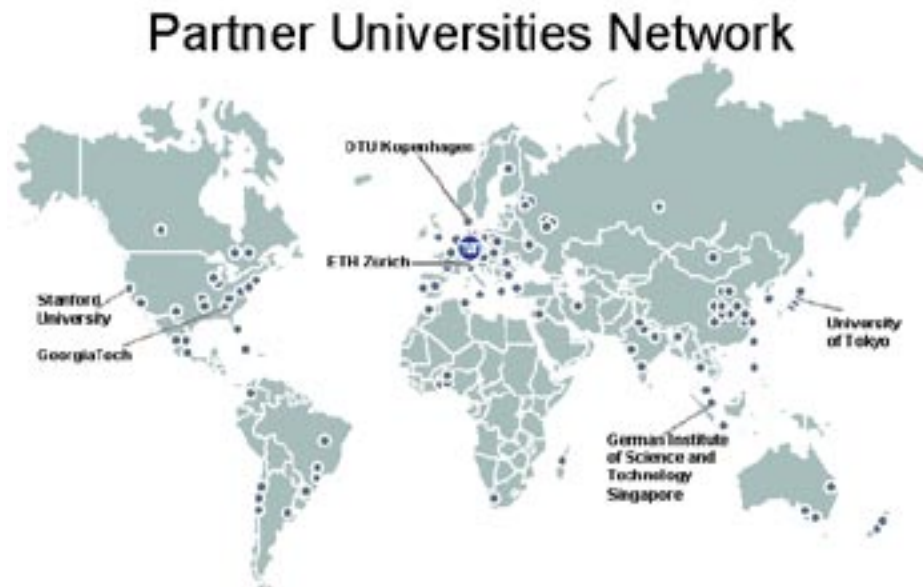


Figure 3. Partner universities network.

As I mentioned before, you need strong disciplinary strength in order to be able to keep up with what's going on in the world. Equally important is inter-disciplinarity. Since you are establishing KAUST now, you are not bound to traditional organizations. In our university departments lose their importance. They are good organizational forms for teaching and for other structural activities but certainly not for research. In fact, the truly new things happen within the borderlines of the classical disciplines. We also have formed Corporate Research Centers in our university, such as instance medicine and nutrition. Bridging engineering and science with computer science and biomedical engineering also is one of our specific advantages.

Our university is defined to serve the society in the first place. Therefore, we have to

consider the development of society. As a public university, we have to be in touch with politics and government. On the other hand, we have to interact with the national education system because we are eager to get the more brilliant talents as early as possible from high schools into our university. Even being an international university, we very much have to depend on our talents, boys and girls from our homelands. I think you are heading towards the same goal, and for that reason, the interaction with the educational system is important beyond the international student exchange. At the same time, it is necessary to consider the present situation in industry and economy. The global labor markets actually are the targets we have to meet, and therefore teaching and research have to change and adopt steadily.

The principle of competition is number one in our university. For that reason, we have just chartered the TUM Institute for Advanced Study. This is the place where the most brilliant researchers, old and young, experienced and fresh, get together to perform research in small communities without writing extra proposals and producing all this paperwork we are used to. Elite university means top-level research, that's number one. But as was mentioned earlier, excellent training and teaching are the ideals of the university to educate young people on the forefront of scientific and technological success. It is necessary to include the young people, the fascinated young people, in the progress of science because this is a life-long experience which makes what you call a research university.

You may be aware of the so-called German Excellence Initiative. In Germany, for too long a time, equilibration of the educational and university system was part of the German federal politics. Last year, an Excellence Initiative was started which put 1.9 billion additional euros into certain universities that were successful in the competition for ideas, projects, and corporate concepts. There were three funding lines – graduate schools that will modernize graduate education, research clusters, and interdisciplinary research. Fortunately, we were one of the three successful German universities in this competition. Interestingly, all three of them – our university, our neighbor university Munich, and the University of Karlsruhe – are located in the south of Germany, which tells you something about the funding situation within Germany. With this additional money we are able to charter new institutes, interdisciplinary institutes, new research projects, and a Graduate School of Science and Engineering. We believe that there are many benefits if we are able to bring scientists and engineers to work together. There are still too many differences between these two different cultures. Not only humanities and engineers are different, but also scientists and engineers.

Our institutional strategy was entitled "TUM: The Entrepreneurial University" because this is a fundamentally new task in Germany. We are on the forefront of this development with the key being competition. And competition once again in a set of measures oriented to its top research, we started the Institute of Advanced Study. We have numerous examples to comprehensively support the university community. We are very engaged in gender and diversity issues, which are still far behind in Germany, and we have measures to invest in a sustainable way. Our strategic

partner universities include Stanford, Caltech, National University of Singapore, University of Tokyo, and a few universities in Europe such as DTU Copenhagen and TU Eindhoven.

In a technical university, close relations and cooperation with industry are a key factor to success. We have been collaborating with emerging industries since we have been in existence. In our university at the end of the 19th century, the air liquefaction was invented by Carl von Linde. Von Linde's company is now active throughout the world as a leading player in advanced technologies. The diesel engine was invented by our former TUM student Rudolph Diesel (Figure 4). The engine is very old but it is still working, and we have many other successful scientists and engineers in our TUM family. We are very much looking forward to be intimately associated with the new enterprise here close to Jeddah in Saudi Arabia.

TUM. Inventors and Entrepreneurs.



Figure 4. TUM's inventors and entrepreneurs.



Dr. Mohammed I. Al-Suwaiyel
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for Science and Technology
Riyadh, Saudi Arabia*

Dr. Mohammed I. Al-Suwaiyel is president of King Abdul-Aziz City for Science and Technology (KACST), holding rank of a Minister from 1 July, 2007. It is a new position that he has assumed this year after having spent the past number of years at King Fahd University of Petroleum and Minerals (KFUPM) and as vice president of KACST, the cousin of KAUST. KACST is a government institution in Saudi Arabia charged with the development of science and technology and is the main research engine within the country.

Dr. Al-Suwaiyel obtained his B.S. degree in general engineering (systems) from King Fahd University of Petroleum and Minerals in 1972. He received his M.S. and Ph.D. degrees in 1975 and 1979, respectively, in computer science (algorithms) from the University of Southern California.

He worked at KFUPM as chairman of the Systems Engineering Department, chairman of Computer Science Department, and dean of the Computer Science and Engineering College. He moved to KACST as vice president for Research Institutes from 1991 to 2003. He was governor of the Communications and Information Technology Commission from March 2003 till June 2007. He is a member of the board of directors of a number of organizations; the most recent of them is the Board of Directors of Saudi Aramco since 2001.

Dr. Al-Suwaiyel has given a number of courses in computer science, computational mathematics and data security at KFUPM and King Saud University. He has published a number of conference and journal papers in international and regional organizations. His research interests are in the areas of computational complexity, cryptography, and data security.

One thing I can tell you about Dr. Al-Suwaiyel – I contacted one of the people I know in his institution and asked him to tell me what he expects the future to look like under Dr. Al-Suwaiyel, and he says, "His Excellency Dr. Al-Suwaiyel is a true scientist. He loves and appreciates science. Under his leadership, KACST will emerge as a vital source of innovation and an essential player in the country's development."

The Role of the Research University in the 21st Century: Scientific and Economic Aspects

Dr. Mohammed I. Al-Suwaiyel

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As a proponent of science and technology in this country, I am ecstatic about the birth of KAUST, and I truly appreciate the vision behind it and the visionary who is the Custodian of Two Holy Mosques. I also appreciate the great work done by Minister Al-Naimi, Mr. Abdallah Jum'ah, Mr. Nadhmi Al-Nasr, and all of our esteemed colleagues who worked hard to bring this vision to life. By doing this they breathe new life into academia in this country, and I thank them very much for it.

When Dr. Ulaby asked me to speak on all or some of the four points covered by this symposium which are (1) future challenges and opportunities, (2) investment in basic versus applied research, (3) new economic model for university research funding, and (4) advice to KAUST, I thought that was very nice of him. He gave me freedom of choice and freedom is a buzz word, especially for KAUST. I like the analogy he just mentioned that KAUST and King Abdul-Aziz City for Science and Technology (KACST) are cousins and they only differ in the third letter. KACST looks forward to strong links in many ways with its new cousin.

Choosing one or all of the four points was a tough problem by itself. I decided to try to answer each of the four points. However, this approach is risky because speaking on all four points the probability of being wrong on one or more of the points is higher than the probability of speaking on less than four points. Therefore, I have a higher probability of being wrong, but to be wrong is for sure the way to discovering how to be right, and this is one of the basic premises of science.

To address the first issue, the challenges and opportunities for a university in the 21st century, I will start with what is known by many that computational science is becoming the third pillar of science. Many, many years ago, we only had observations and experiments, then theory, and now computational science. Let me just say a few words in support of this hypothesis, although it may not be a hypothesis any more.

Science discovery is being increasingly driven by massive computations and massive data analyses. These computations entail computational science. The science discovery process starts with observations, data gathering, data farming, archiving, indexing, searching, looking for patterns, and then may be with a little touch of inspiration you have a discovery. All stages of data gathering, archiving, analyzing,

and searching involve intense computations. This is what is meant by computational science being the third pillar.

The main components of computational science are the algorithms, the computer and information sciences, and the computing infrastructure. In the rush of doing things, many of us tend to equate computational sciences with raw computing power, with faster computers, and faster networks. More emphasis should be given to algorithms. Algorithms are the drivers of all the computational engines. The better algorithms you have, the faster and more efficient computations you have.

Computational science is becoming an enabler for the developing and under-developed countries, and we definitely see it in this part of the world. Computational science is improving health, education, transportation, and communications and other facets of life. It is also a driver for advanced countries. Computational science has provided us with the tools to solve complex problems in many domains that impact our day-to-day activities.

Bioinformatics specialists and biochemists know what computational science did in their fields. Lately, computational science is stepping into dangerous domains, dangerous as far as mathematicians are concerned. Some computer-aided mathematical proofs are being offered today. We have seen the four-color problem proven by computational methods. Recently, a few weeks ago, we saw computer-aided proofs for the E8, the symmetry group problem. I am sure that many mathematicians do not like this. We also have seen how computational sciences contributed to bioinformatics in the genetics domain. Many new results were only possible by using the recent computational tools.

Computational science requires tremendous resources, but no matter how much resources are available, there are problems that cannot be solved or that need months or years to solve even if we have all the supercomputers in the world. I think this is a challenge for KAUST, especially for one fourth of the university which worries about applied mathematics and computation.

There are problems that we have today for which no efficient algorithms exist and yet nobody has proven that no such algorithms would ever exist. A major research effort is needed here because of the difficulty of these problems. If we can find "more efficient" algorithms for one or more of these "computational hard" problems, then this will be a truly great achievement.

One of the most famous examples of a hard problem is: $P = NP$? Most of the present problems fall in one of two categories. Those that are solvable fast are in the P class, and those that are not solvable fast are called NP. It is like many dichotomies in nature but nobody, so far, has answered the question $P = NP$? It is a difficult question whose answer will put to rest many open problems. It is a one-million-dollars prize problem, and I hope this prize would be won by KAUST. I expect that to happen.

Implications of computational sciences present challenges and opportunities for academia. A report written for the President of the United States says universities must implement new multidisciplinary structures to prepare for the growing ranks of computational sciences.¹ Let me elaborate a little bit. Mathematics in the 17th, 18th, 19th and even 20th century did wonders for the science, and in the beginning mathematics was just one department but then engineers have to learn a lot of mathematics. When I listen to some engineers, especially electrical and mechanical engineers, they sound like applied mathematicians. Now, I believe computer science and computational science would do what mathematics did in the 17th to 20th century. From now on, everybody will have to have computational tools, and by tools I do not mean raw computing power but algorithms and knowledge of algorithms to solve the problems. Therefore, a little bit of computational science has to be addressed in each discipline, and this is an opportunity for a starting university like KAUST and a challenge as well.

The second problem or question posed for this symposium was the investment in basic versus applied research. I would like to start with a quote from Hardy,² a famous pure mathematician, who died in 1947, and said "I have never done anything useful, no discovery of mine has made or is likely to make directly or indirectly, for good or ill, the least difference to the amenity of the world." How wrong he was! Only 30 years later, his Work in Number Theory is the basis for secure data communications that you use when you access secure computer sites or do electronic transfers. His work is an example of very pure research that turned to be applied in a short period of time.

Before the 1970's, basic and applied research were believed to be different disciplines but after the 1970's, information technology and bioinformatics have shattered this belief. The divisions between basic research and applied research are blurred or becoming minimal. I was happy to hear this morning what Dr. Rhodes said, "that the design and fabrication on the level of an atom, science, and engineering are the same." Thus, applied and basic research is not that different anymore. I will venture an answer on how to balance the investment, and that is we'll do better if we fund a mix of applied and basic research that will have maximal positive economic impact.

In the case of the third question, the economic model, I will begin with some questions. Are there formal alliances and partnerships between universities and industry? Of course, yes. Are universities becoming R&D departments of industry? Yes, maybe some would not admit it, but I believe that the answer is yes. Are universities becoming innovative companies? I would venture to say yes. Are universities producing original work? I hate to say it but I think the original work done by universities has taken a second seat to the requirements of the industry and the sources of the fund.

Let us look at a model for university research funding. Originally, there was budget-supported research in universities. Then private investments came from many

different sources. Most of the private funds go for technology transfers with the ultimate objective of manufacturing and sales, and a small part of the funds go for developing lab prototypes. There is a funding gap between the lab prototypes and industry prototypes. I anticipate that a good part of this gap will be covered by funds coming from universities. Universities may take on more of the roles of a venture capitalist. Probably KAUST, with the generous endowment it has, will be along this model or very close to it. I think the model we need is the one that defines a true partnership between universities and the venture-capital community. The model should allow the research university to contribute financially and technically in the form of support and become part of the venture capital.

The last question is giving advice to the KAUST President. KAUST, as we envisage it, is a global university that serves Saudi Arabia and the scientific community-at-large. KAUST will have Saudi elements, faculty, students, and staff. It will have links to the local and international industries as well as to other academia and universities. As we mentioned, there should be a humanizing element, that is, an association with the local culture and with the local community. I think the President of KAUST and his administration will do well if they integrate into the local society, the local academic and research community, and pull them along to excellence with KAUST. Yesterday, I had a talk with the Secretary General of the Organization of Islamic Countries, and he talked about a plan to have a number of universities in the Islamic countries to be among the top 500 and a smaller number in the top 100. I think the presence of KAUST will help realize this plan.

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Dr. Olivier Appert

*President and CEO, Institut Français du Pétrole
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Dr. Olivier Appert is the President and CEO of the French Institute of Petroleum (IFP). He has held that position since 2003.

Prior to this, he served as director of the International Energy Agency's Long-Term Cooperation and Policy Analysis Directorate, beginning in October 1999. From 1998 to 1999, Dr. Appert was the senior executive vice-president of ISIS, a technology holding company that is a publicly listed subsidiary of the IFP. From 1994 to 1998, he worked as executive vice president of the IFP in charge of research and development activities. From 1989 to 1994, he headed the oil and gas department of the French Industry Ministry.

Dr. Appert also served in the private sector from 1986 to 1989 as vice president of the Philips group for mobile radio activities and strategy. He was executive director of the French Industry Minister's office from 1984 to 1986 and served in Prime Minister Pierre Mauroy's office from 1981 to 1983. Dr. Appert is a graduate of the École Polytechnique and École des Mines.

I tried to find some information about him and I spoke to a knowledgeable source in the oil industry. He gave me a quote in French which I quickly put that through Google translator and it came up with "Monsieur Appert is a superb strategist with a keen sense of vision."

The Role of the Research University in the 21st Century: Scientific and Economic Aspects

Dr. Olivier Appert

*President and CEO, Institut Français du Pétrole
Paris, France*

It is a great honor for me to participate in this panel. In the context of creating a new research university in Saudi Arabia, our task during this session is to cover the science, technology, and economic development aspects.

Clearly, research and education are key success factors for economic development. They have to be linked with the major societal challenges such as natural resources, energy, and environment. The role of the university is also to provide tomorrow's scientists, engineers, and economic leaders, thanks to first-class initial education as well as continuous education. In my presentation, I will focus on the second question on the link between education, science research, applied research, and industrial development. I will also offer some advice to the Founding President of KAUST and his/her administration.

I would like to draw the lessons from our experience in France. As you know, France has always had very small oil and gas resources. However, some French companies are among the world leaders. Total is the fourth international oil company (IOC). Technip and CGG Veritas are major players in upstream and downstream engineering and in seismic. I would like to mention that the French Institute of Petroleum (IFP) is well-known worldwide in oil and gas technology and education.

This is the result of a strong policy which has been implemented since 1945 in order to develop technologies and human resources. The development of French companies and institutions has been based on advanced technologies and well-trained engineers. Technology and education have been the key success factors of our development. They will be the key success factors of KAUST.

What are my answers to the second question? Too many people are opposing basic science and applied research. For them, the sole objective of science is to develop knowledge. At IFP, we consider that there is a continuum between basic science and applied research. I would just take the example of Yves Chauvin who received the Nobel Prize in Chemistry in 2005. During his career at IFP, he developed the theory of metathesis for which he received this award. But at the same time, he developed new refining and petrochemical processes such as Dimersol which is widely used in the industry.

Basic science is needed to bring solutions to bottlenecks in industrial development. And vice versa, industrial and societal demand may open new fields for basic science research. Louis Pasteur, the famous scientist of the 19th century, gives us a good example. He killed the concept of spontaneous generation. He rediscovered the microbes which have been already observed. He understood the origin of many diseases and found how to cure those diseases. The institute he created is always covering both fundamental and applied research. In the future, we may consider, for example, that modeling from nanoscale to microscale in the chemical reactors will imply a continuum between basic and applied research. A successful continuum can lead to world-class companies as we are experiencing now at IFP.

Innovation is often coming from cross fertilization between disciplines. I will give some examples. The dramatic improvement of aircraft engine has been achieved, thanks to breakthroughs in materials. The same breakthroughs have been used later in power generation. As a result, very efficient combined cycle gas turbines are in operation worldwide. In the field of computer science, the technologies or methodologies developed for one discipline may be applied in another. This is, for example, the case of LES (Large Eddy Simulation) which is implemented in reservoir simulation as well as in combustion simulation. Chemical modeling is another example. This new discipline is useful in the fields of catalysis and chemical processes but also of combustion.

Our long-lasting experience has convinced us that it is very important to create a strong partnership between the R&D community and the industry at large. This creates linkage between fundamental or applied research and the societal needs at large. Somehow, it is ensuring that research is not useless or going to a dead-end. At the same time, this partnership contributes to R&D funding which is always helpful. As a result, this cooperation helps create technological companies as well as jobs. This is a key target for KAUST.

Education plays a key role in any research university. Research activity is a well-recognized way to train engineers. There are many examples of researchers who became leaders in the industry. Ph.D's and post-doctorates are also very important contributors to research activity within laboratories. Usually, they bring new ideas and are enthusiastic about their research. Therefore, a research university contributes to graduate engineers for research laboratories, but more important for the industrial sector and more widely to become economic leaders. In that sense, alumni are a very important link between the university, the departments, and the industrial world.

Building on our experience at IFP, what are the advices that I can offer to the Founding President of KAUST and his/her administration? Recruitment is the first priority. It is necessary to recruit as soon as possible the faculty. But at the same time, students should be recruited. This is a major challenge due to the very tight time-frame for an effective launching of KAUST in September 2009. It is also mandatory to maintain a good balance between education, basic science, applied research, and industrial development. At the beginning, a focus should be put on education and basic

science, but rapidly it will be necessary to consider applied research and industrial development. KAUST should be open to all cultures and to consider the international scene. It is clearly part of the vision of the King. The Founding President of KAUST should be determined to pursue this objective. Last, but not least, the Founding President should be patient and persevering. Setting up KAUST will take time and will require perseverance.



Dr. Robert A. Brown
President, Boston University
Boston, Massachusetts, USA

Dr. Robert A. Brown, a distinguished scholar of chemical engineering and an innovative leader in higher education, became the tenth president of Boston University in September 2005. Dr. Brown, earned B.S. and M.S. degrees in chemical engineering at the University of Texas, at Austin. He received his Ph.D. in chemical engineering from the University of Minnesota. He is a member of the American Academy of Arts and Sciences, the National Academy of Engineering, and the National Academy of Sciences as well as other professional societies. Dr. Brown was provost and the Warren K. Lewis Professor of Chemical Engineering at MIT immediately prior to his appointment at Boston University.

Dr. Brown joined the MIT faculty in 1979, beginning a distinguished career in education and research. He has published over 250 papers in areas related to mathematical modeling of transport phenomena in materials, and served as executive editor of the *Journal of Chemical Engineering Science* from 1991 to 2004. In his twenty-five years at MIT, he held several leadership positions including head of the Department of Chemical Engineering and dean of the School of Engineering. During his tenure as provost, which began in 1998, Dr. Brown oversaw the establishment of several major interdisciplinary initiatives, including the Singapore-MIT Alliance, a partnership in graduate engineering education and research between MIT and two universities in Singapore, and the Broad Institute, a multi-institutional collaboration in genomic medicine.

Dr. Brown is actively engaged in both the public and private sectors. In February 2006, President George W. Bush appointed him to the President's Council of Advisors on Science and Technology, a panel established to provide a steady stream of expert advice on a wide range of scientific and technical matters. He has served as a director of the DuPont Company since April 2007.

Dr. Brown is chairman of the Academic Research Council of the Ministry of Education of the Republic of Singapore, a key funding body for academic research in that country. He previously served on the board of Singapore's National Research Foundation. In recognition of his extraordinary contributions to higher education in Singapore, Dr. Brown was named an honorary citizen in January 2006. This award is the highest form of recognition given by the Singapore government to any non-Singaporean.

Recently, he introduced a strategic plan for the Boston University and a member of the faculty describes his strategic plan, which is called Forging Our Future by Choosing to Be Great, says "He articulates exciting goals that will propel Boston University to becoming among the very top universities in the country."

The Role of the Research University in the 21st Century: Scientific and Economic Aspects

Dr. Robert A. Brown

*President, Boston University
Boston, Massachusetts, USA*

Excellencies, colleagues, and ladies and gentlemen, it is an honor to share the stage with such a distinguished panel and to be with you on this historic occasion for the groundbreaking of KAUST and for the symposium. I realize that I am the last speaker of the day. There are so many things that have already been said, so I will take the liberty to speak very specifically about really one of the questions. But before I do, I would like to just give you a bit of a historical context.

It is indeed a singular event in the history of higher education where such a magnificent act of vision and philanthropy has been involved in the creation of a new research university. In fact, I can think of no other time in history when an institution has been started with the potential for such impact. I like to think of myself as an amateur historian. I rummaged across the web and through books that I have looking for a parallel situation in terms of the birth of universities, especially for a private university with an impact on science and technology. Essentially, all others pale by comparison.

For example, the only other one I can find that is really analogous was William Marsh Rice's gift that started Rice University, in Houston, in the year 1904, with a bequest that set the stage for the great university that exists today. At the beginning of the last century, when Rice intended for founding the university based on undergraduate education, he started with the bequest of 4.6 million dollars, a little less than 100 million dollars in 2007 terms or over a 100 times less than the support of KAUST. Now, we look at Rice University over a hundred years later, and we see a great university. My sense is that with the magnitude of the resources available and with the support of the Kingdom, we should expect KAUST to be much more ambitious and not content with anything less than the establishment of a sustainable graduate research university of truly international quality in much less than a century.

One of the goals given to us was to give advice to the new President. Others have spoken about many aspects of this. What I would like to do is speak just for a few minutes about the organization of KAUST and give advice in that framework. My remarks are in the context of how KAUST can best establish itself to fulfill three critical roles of a research university – to provide graduate education of leaders in research and technology, to nucleate important advances in science and engineering for the good of society, and to be a mixing ground for ideas which are distilled totally on the basis of merit.

Given the wonderful possibilities for exciting engineering and science research that

can be catalyzed by a new research university of this magnitude, it is easy to think about the organization of the enterprise. It is easy to think that it does not matter and that one should simply adapt the tried and true approaches of others. This line of reasoning leads to traditional academic departments, that may or may not be in schools and colleges, as units, shown here where I denote them as physics, chemistry, mechanical engineering, and chemical engineering – my own home department. This is the simplest organization as you get the attributes that every university leader feels most comfortable with, home of traditionally based academic units, especially undergraduate education. KAUST is free at least initially from this constraint, unit-based governance and direction which can easily be copied from others around the world. Best practices sometimes reduce us to the same old practices and that is a constraint.

Traditional mechanisms for research directions are on a disciplinary basis through academic departments. The most important role of education is in fact the higher level of innovation and here the disciplinary approach may constraint creativity, especially at the boundaries of disciplinary thinking. Finally, academic departments are more or less right-sized organizational units for creating a sense of community among faculty and students in a much larger organization. This role cannot be over-emphasized. Any organization, even of the small size, has to have a smaller granularity in which we create intellectual homes for the students and faculty. This feature is needed in KAUST.

There are problems with the academic disciplinary approach, and in spirit of a late afternoon discussion for an audience, some of which have jet lag, I offer this image as a starting point for my discussion. These departments can, in many cases, form the organizational equivalent of medieval fortresses intellectually, pragmatically, and sometimes even physically if you agree to build appropriate buildings. Now there have been many efforts to bridge these structures, especially in the names of creating interdisciplinary efforts in research and education. The concepts of centers, laboratories, and institutes were born in the last century as research universities emerged and the need was realized for organizations that would bring faculty and students together across these disciplinary boundaries. In science and engineering, many of these centers also had several common themes. They created the opportunity for mission-oriented research thrust and hence were created along the lines of societal problems, and they also were facilities. They re-established critical research facilities both in equipment and staff that might not be the highest priorities for academic disciplines.

Finally, and we should not lose sight of this. In many cases, they were created to attract funding in competitive funding systems where mission-oriented research was necessary, at least on paper in order to secure funding from agencies. In fact, many centers and institutes in the United States were born from proposals and some, not the ones that have been successful, exist almost in name only. To be fair, there are many centers which have thrived with these missions although with difficulty. They typically occur in the matrix form of management, and anyone who has worked in matrix organizations understands this.

To carry my medieval analogy a bit further, you can see the negotiation of a center director between two academic departments might look something like the following,

especially when precious resources like faculty positions and money are involved. KAUST has proposed to form four academic centers or institutes in key areas without the burdens of departments or schools and colleges. This is a very interesting approach and novel, but it is not without danger. Strong center directors can create barriers as large as any that have been created between academic departments, and in fact, you have the risk of inverting the system in changing the slide to be one where the centers or institutes are castles and the departments and disciplines live outside.

Using this perspective as a basis, I would like to offer four points of advice to the leadership of KAUST. First, and this is the key, and it has been said by many people. The first challenge for the leadership is to create and to choose a faculty with world-class disciplinary expertise that have an exceptional desire to collaborate with others and to contribute to the solution of grand challenges. How? Use collaboration as a criterion for hiring along with the highest standards of research excellence. Secondly, you create incentives to promote behavior through mechanisms for research support; I will come back to this. The faculty that will be hired as the permanent faculty of KAUST must be committed to the institutional mission of the organization and to the concept of a residential university, what we saw in the beautiful model yesterday for its students and faculty. This is especially true for the young faculty who will truly define the future of the institution.

The second piece of advice is the attempt to conceive, create, and operate a world-class educational program without creating either departments or centers and laboratory structures that are overly restrictive. This will be difficult as the natural nature of a university will be for such organizations to form. Leadership will be required but leadership alone is not enough. Incentives will be necessary. Incentives can come along the lines of promoting interdisciplinary collaboration through long-term support of research on grand challenges that cut across disciplines. Support research efforts that are large scale and not easily addressed by individuals or multi-investigators. These research projects should finally be high risk and high impact that span from basic science to technological development and be rigorously evaluated across all research areas. This step of rigorous evaluation by peer review, in most cases, will be through external consultation and will be critical to creating an elite research culture within the institution.

There are other things one can do to create this kind of environment that encourages cross fertilization and debate. You can create university-wide lectures, promote business and entrepreneurial development, and create a spirit in which integrating economic and public issues into technological development are fostered within the institution. This will mean incorporating management and social sciences into the institution.

This last point leads to a point that has been addressed by a number of other people. It is that once the institution starts reaching out beyond science and engineering, for example, into management and social sciences and develops those interfaces, it will put pressure on the university to expand – to expand its faculty into these disciplines, into social sciences and into management. This is not a move away from science and technology but a move that embraces the concept of leadership – leadership that is needed to be instilled into the faculty and into the students of KAUST to take them

from being simply engineers and scientists to being those integrated leaders of the next century.

Science and engineering in a vacuum will not lead to this type of leadership and will limit the proposed creativity of the solutions to grand problems that KAUST faculty may engage in. KAUST is simultaneously a noble and ambitious dream to create a world-class university for science and engineering in the Kingdom of Saudi Arabia and an opportunity to create a new educational institution that emphasizes the role of inter-disciplines and collaborative research and education for addressing great problems. I hope you will seize this marvelous opportunity.

Question and Answer Session

Question

My name is Mohammed Badri from Schlumberger Dhahran Research in Saudi Arabia. The question I have is what are the performance indicators that KAUST will be using to measure their successes against their objectives for achieving the ultimate goal?

Answer

Dr. Al-Suwaiyel: Traditionally the quality of students, the quality of the research output, and the contributions to the society and industry are very important parameters which will gauge how far the university accomplishes its goals. These are the normal parameters. My distinguished colleagues may have other more subtle parameters.

Dr. Holbrook: I think you will have both soft measures and quantitative measures. With quantitative measures, it will be a little harder because when we measure research in our universities, we often measure the research quality by the amount of investments that is put into it. KAUST, of course, will have investments initially under research enterprise but KAUST will also be seeking external funding for some of its research. External partners can be used as one measure. KAUST will still have the same publication standards of all great quality universities and publications will certainly be a measure. I think that patent licenses, royalty, income, the kinds of products that are commercialized and the amount of technology that get moved to the marketplace and their benefits for society are also measurements. For its students after graduation, whether they stay in the Kingdom and continue working with Saudi Aramco or whether they will go to other great institutions around the world can be seen as measurements. Some of them we hope will become great professors, and what institutions they join after they have completed their degrees are measures of success or partial success of KAUST.

Dr. Brown: I think this question is one of the great challenges for KAUST administration because small countries that are emerging with significant research efforts in their universities will invent a system internally to obtain assessment on an ongoing basis for their research productivity. When you start coupling this into personal decisions like renewal of contracts for a faculty in a non-tenured system, you couple into awarding internal research money to

individuals. In a small environment, you would have to use a review system for both that involves the entire international research community. I am really hardened by the fact that as KAUST is coming into existence it has gone to that community right off the bat to get all the advice about what a great university offers. But it will have to invent a system to do that internally.

Dr. Herrmann: A short-term soft measurement will be the quality of corporate identity that you develop which is an important entrepreneurial value. This depends on how the students and professors fit together – whether they like to have a scholarly environment that they can form together. This could be a goal for the short term. For long term, it is the multiplication effects on academia and industry – how many excellent academics you generate and how many successful businessmen, engineers, and scientists make their way in industry.

Dr. Appert: The board of administration will have to decide on a set of criteria covering both training basic science and applied science. As far as training is concerned, I think one factor is how long it would take for students to find a job – would it be a few days or few months? As for the basic science, the number of publications is a key indicator. For applied research patents, as been said before, are very important – the number of patents as well as the number of collaborations with the industry. If KAUST is successful, it will attract industry. The share of funding from industry to research activity may be used as a criterion.

Dr. Ulaby: Let me add one more criterion and this is impact. A faculty member can publish a paper once every four years. But if that paper is read and cited by 500 people, that paper will have had so much greater impact than a bunch of papers that nobody has read or cited. It is the integrated quantity and quality, and eventually the impact of that work on the scientific community which I think is very important.

Question

I am John McCarthy, director of Manchester Interdisciplinary Biocenter, at the University of Manchester. I just like to respond to some of the comments about the issue of balance between interdisciplinary and monodisciplinary units in university. This is becoming a key issue for many universities around the world and will be one for KAUST. Sometimes when I hear discussions like this, I hear a lot of comments about the problems. Of course, we face a lot of problems in our institution. I can assure you that. But I do feel that there are many ways in which they can be dealt with because work at interface will be increasingly important. We have to manage them properly and that one of the issues is that all of these potentially damaging problems could be dealt with if we have good management in universities of the various issues that arise. The other thing is incentives which people have mentioned. I think when we are talking about homes and mentioning this matter, you cannot be at home in an institute, in any

disciplinary community, or in a school that you share. Ultimately, I think it is very important that individuals and university fulfill membership and commitment to the wider community of the university. If we share that goal, this problem of potential conflict disappears because if you are committed to the strategic goals that are clearly identified by the university, then you will accept that you have shared legends to different types of community. I really think we have to try and make sure that these conflicts are dealt with. I think that we will accept there is a need for a far better infrastructure in our educational and research institutions for interdisciplinary research. I would address this point to all on the committee. I have not raised a specific question but I would be interested in your responses to what I said.

Answer

Dr. Holbrook: I think your point is extremely important. It is one that established universities rustle with all the time because of the great silo mentality because when resources are involved, each person wants to get credit for those resources. That really establishes a very difficult bridge to inter-disciplinarity in many institutions. KAUST, of course, is in the enviable position, as I said, of starting fresh with those kinds of things built into the infrastructure on how they will work. Just to address the topic in general, I think faculty left to their own devices will become interdisciplinary. It is absolutely essential because the problems of the world today are so complex that they will never be resolved. As you know very well interdisciplinary interactions require the thinking of all kinds of different people to come together to really forge the right solutions and to bring together a lot of creative minds. Faculty always migrates in this direction and it is usually the administration that botches up the situation so that it does not work terribly well. This is where KAUST is really at an enormous advantage I think.

Dr. Herrmann: Inter-disciplinarity certainly belongs to the mindset of an institution. Traditionally, you are at home in your department of chemistry and physics. We have seen this wonderful set of pictures. I think if an institution, like a university, prepares for inter-disciplinarity and supports specific measures to gear up the inter-disciplinarity, then you will find that young people will go there, such as our graduate school of science and engineering. It sounds trivial but still if you look around, scientists and engineers normally have different ways to do research, to think, to make decisions, and so on. It is important to include the young brain on interdisciplinary topics and complex matters. These days, research is extremely complex and not a chemist, a biologist, or a physicist can do it alone. If you support this idea, then things will just come along by themselves, so it is important to have young talented people.

Question

I am Ed Hundert from the Washington Advisory Group. I want to ask a question about the topic that a number of speakers, both this morning and this afternoon, asked about the humanizing of knowledge and culture of KAUST and the four institutes that will be the main organizational principle for the research at KAUST. The plan at KAUST involves creation of four horizontal programs – a program in entrepreneurship and innovation, a program in communication skills, a program in teaching and learning of science and technology, and a program in science technology in society. So far, the only definite organizational structure within the program in science technology in society is a program in the Center for the History of Islamic Science and Technology which is very exciting, but the rest is still a blank piece of paper. It could start out with the focus on ethical issues in science and technology and literate in science and technology and social science in science and technology. I was wondering if the panelists can comment. The question is where to start if you are going to bring in the social sciences and humanities that so many people have suggested. You cannot do them all – which areas of the social sciences and humanities in that program in science and technology in society would you think will have the greatest impact in creating these future leaders?

Answer

Dr. Brown: I would not end every phrase with the phrase science and technology. I would take humanities for humanity sake. Assume that you are going to be bringing into KAUST students from all over the region in the world. Why would I teach Arabic? I would teach Muslim culture and religion. I would teach the history of the region and as I said humanities for humanity sake. You tell the students that they have a rare opportunity, the opportunity not only to come to a world-class institution of science and technology but also the opportunity to live in a region of the world and learn how that region of the world thinks, acts, its history, its cultures, and its archeology. You tell the students to fuse all these experiences while they are here. I would use the phrase that we use in the United States, a liberal arts education – a small step to take advantage of the location.

Dr. Herrmann: I did have the same problem in my university, but I am convinced that a technical university tomorrow can only be successful if it is related to the humanities and social sciences. We solved the problem by introducing the academy as a corporate institute and made some curricula in the humanities and social sciences mandatory for every student. There were certain lectures from which the student could pick two or three during the entire study course. Maybe a similar approach should be established at KAUST. I am convinced that you should do it.

Dr. Ulaby: One should remember that KAUST is a graduate school only and usually the humanities and social sciences are introduced as part of the undergraduate education.

Dr. Al-Suwaiyel: We still have skeptics who do not think science can contribute to the average man's life. When this university gives concrete proofs of how this would change the lives of people in this little village, the country, the region, and the Organization of the Islamic Countries, I would think this is humanizing – making sure people realize that science is giving them concrete day life issues.

Dr. Holbrook: I think it is a terrific opportunity for KAUST to really get engaged in problem-based learning. Here is an opportunity to design questions in science. First of all, I think scientists have a responsibility to society. There is no question about that. There are so many issues that arise in scientists' lives that they need to consider. Here you have a global community that may think about things very differently. What I would do if I were in this environment is that I would pose a number of questions that certainly would arise during the enrollment of a student while at KAUST. Let the students participate in the design of those questions as well as other issues that may come up. Set up seminars and talk about these issues and how people would address and resolve them. It would be good to have these interactions because it is a wonderful opportunity for a real exchange of ideas. A classroom-structured humanities exchange can also be set up.

Dr. Appert: I think that what is quite often missing to engineers or researchers is a sense of management. Introducing management would touch upon many social sciences and I think that is very important to create economic leaders to bring within KAUST some sense of management.

Question

I am Bashir Dabboussi from Saudi Aramco Research and Development Center. There has been a lot of discussion about attracting talent into KAUST. My question is how do we retain and how do we sustain? I appreciate from the panel their input on their experiences over the past 10 years in retaining the top talent in academia. Have they seen a sort of departure of some of the top talent into other areas in finance, industry, and so on? Has the structure that has been established in entrepreneurship really kept talented faculty members and other people in their positions? I would appreciate if that can be related to how KAUST can sustain in 2009 – how it can sustain the momentum and keep people in place?

Answer

Dr. Ulaby: I think we need to have a free flow of people between academia and other segments of society. People who spent their entire careers in academia, they

do it by choice and it is not because of the money. Clearly, there are many other opportunities outside of academia where people can make a lot more money than academia can offer. However, over the past 20 years, especially in the sciences and engineering, there has been an emergence of the entrepreneurial faculty which really did not exist 25 or 30 years ago. The individual who not only wants to do research, publish, supervise graduate students, and all the traditional academic pursuits but also would like to see the product of his or her research come to provision in the form of a product or a process or something that benefits society in a direct fashion. Universities were reluctant to support that type of idea 30 years ago. Universities are very supportive of that today. That process is working very well which means for those of us who would like to be part of academia and at the same time enjoy that role of participating in transitioning technologies and discoveries into the private sector, we are able to do so. So I do not see it as a concern because people will eventually define themselves and their roles. Some will end up staying within KAUST because KAUST is the right environment for them, while others may feel more comfortable pursuing an industrial job.

Dr. Holbrook: I think what you said is exactly right. I think you said one word that is very important, two actually – environment and opportunity. I think the way we sustained faculty is to give them opportunity and you mentioned one kind. I also think that the environment that they live in is very important to them – that they are surrounded by colleagues who are extraordinary and have resources to get their work done when constraints start to be put on them. When they do not have good students and when they do not have their faculty colleagues, then the faculty tends to be enticed to go to another university. So many times, what we end up doing is actually funding or providing more opportunities and resources to faculty members. But I think there are more faculty members who say I came to spend my first two years at your university, and 32 years later I am still here. So, there is something about building an environment that keeps people there to do the things they want to do.

Dr. Ulaby: One of the things that we usually do at the Board of Regents, which meets once for the university, is to receive a list of retiring faculty. The secretary of the university always announces the average number of years of those retiring faculty of the institution and typically that number is between 30 to 40 years. People who are comfortable in their surroundings and what the university offers to them will stay there. In the opening of this session, I talked about migration away from Ann Arbor, but that was really unjust. I did not mean that people are leaving Ann Arbor in big hordes; nothing is further from the truth.

Question

I am Dr. Samar Saqak, from Medical College, of King Abdulaziz University. I have two questions, one to Dr. Holbrook and one to Dr. Al-Suwaiyel. Dr. Holbrook, you mentioned social responsibility – the role of social responsibility with the

business institutions. In Saudi business circles, discussions now are about social responsibilities of mega companies. What would be your advice for all universities in Saudi Arabia? Dr. Al-Suwaiyel, in King Abdulaziz University this year, we have 40 female students who have been funded for postgraduate study. There are four centers of excellence such as the environmental center. In your opinion, what are the challenges that need to be addressed by KAUST if universities are included in the strategic plan for KACST funding all the universities to become 21st-century universities?

Answer

Dr. Holbrook: I am probably not the best one to answer the responsibilities of a mega company to the world. Maybe I could turn it over to one of my colleagues. I have spent my life as an academician and that is a little hard for me to address. But the kinds of things I think about companies is certainly, to be absolutely certain, that they are honest to their stockholders as we know that very well and that they are environmentally conscious. The diversity is a very key portion of the part of their agenda but I am really not the business person who could do that. My colleagues could certainly answer that more effectively than I could.

Dr. Al-Suwaiyel: First of all, thank you for calling the support given by KACST to the universities excellent or tremendous. I think it is much lower than what I would like it to be. The support we gave is a function of the money we received from the Ministry of Finance. However, we are fighting to get more funds to give to the researchers of the universities. I am also happy to see that a large number of females are getting the grants. Of course, I am biased to female students. In my family, the ratio of female-to-male student ratio is eighty-five percent. I have six daughters and one son, and I hope to see all of them getting the grants. What I would like also to convey is that the researcher's, let's say, "compensation," currently is very low, and I will triple it from 2000 to 6000 Saudi riyals. I hope this will provide good support for the researchers. The other part of the question – KACST with the Ministry of Planning and other government organizations drafted the science and technology plan, a long-term plan for 30 years – in the next five years, the plan has a very good budget. It has been allocated with almost 2 billion dollars and emphasizes eleven strategic areas, starting with water, petrochemicals, nanotechnology, etc. These eleven areas will get the top priority and support. The influence of KAUST on this plan will be very positive. We look forward to KAUST being one of the main drivers for some of the technologies. I heard, for example, that one of the priorities for KAUST will be water and desalination. This is in line with the strategic plan and it is priority number one because this country needs water.

An extension to the question, raised by Dr. Khalid Ethabiq, is if we have more money I think we would like to give it all or most to the local universities. KAUST currently is very rich and it may not need our support. We will give priority to the

local universities because yesterday and today, there were questions raised about competition. They say KAUST will take all the support from the local universities. I do not think so. I think it will be a supporter of the local universities.

Question

This is AbdulHaleem from Saudi Oger. I think my question was addressed earlier. I was going to ask about the strategic plans, whether we have strategic plans for research and development in connection to theoretical institutions like research and development in King Fahd University or Aramco Research and Development. To what extent do we try to have our research geared to the industrial or to the human needs? I appreciate the balance between the scientific desires, but I think we should also address the business needs.

Answer

Dr. Al-Suwaiyel: The science and technology plan for the country was drafted in collaboration with the private and public sectors, and many business entities in the country contributed to the plan. The first phase of the plan was to study their problems and requirements. Based on this, the priorities for the plan, the eleven strategic areas and programs, took into account the needs of the local business and local industry starting with Aramco, Sabic, and then to the small and medium businesses. So it is already addressed there. As we go along, we will review, gauge its relevance to the small and medium business, and fine-tune the plan to cater to their needs. We realize that they are a very important part of the economy and they deserve our support.

Dr. Herrmann: I think, KAUST is well advised in designing its strategies to orient the entire policy along the most challenging scientific questions. I think that's the point because then you get the setting at which many scientific spin-offs will result from. Let me give you an example, if you want to activate methane selectively with given unknown catalysts, then that would be a goal worthwhile to run for. If you formulate such a goal, you will have a setting that gives you a lot of expertise in related areas. I think that's the key point.

Question

Ashraf Al-Khairi with the King Abdul-Aziz City for Science and Technology. Is it desirable, appropriate, and feasible for KAUST to offer an award for engineering, similar to the Nobel Prize and the King Faisal Prize for Science?

Answer

Dr. Ulaby: My answer would be for the institution to consider that at some time in the future. It is not something that you want to start with.

Question

Mr. Abdallah Jum'ah, from Saudi Aramco. The question is directed to Dr. Hegarty. Dr. Vest said that crises are the drivers, sometimes for change. Back in 2000, at the end of the last decade when oil prices were in the low-teens, we immediately felt that our national resources would not provide us the step forward although we still have our brain power. We looked actually at no other place than Ireland. We looked at the Irish experience and the change that happened as you mentioned today. I had a question and we really had that question at that time. Of course, Ireland's Trinity College was built in the church's traditions. Ireland is a religious country. If you talk about Catholicism, it is Ireland. Social traditions and religious traditions sometimes are intertwined, so you cannot separate them. I wanted to ask whether the issue of being entrenched in religious traditions a hindrance or a support. Was it an issue at all when the country adapted the new traditions of science, technology, and to the New World?

Answer

Dr. Hegarty: The role of religion in Ireland, as you said, has played a huge role in Northern Ireland and that has only just been resolved, so you cannot ignore it. I think in the South and the rest of the country, in 1950's, Ireland was probably a repressed nation because it was under the thumb of the Catholic Church too much. That has changed and all the social ills of our society have been uncovered over the last 15 years. They have all been exposed. Some of them are not very nice but they have been exposed, they have been debated, and we have gotten over them. I would say that as result, we have, as a society, a great openness to ideas and tolerance of other traditions. It is not that Ireland is a non-spiritual nation; it is a very spiritual nation but it is now a very open one.



Mr. Abdallah S. Jum'ah
President and CEO, Saudi Aramco
Dhahran, Saudi Arabia

The Beginnings of KAUST

I would like to describe the seeds of KAUST, how it began. I was just finishing an executive committee meeting in Geneva, in July of 2006. It was a difficult meeting with my executive committee, which I chaired but did not vote, because I was presenting all the programs. I was asking for around 20 billion dollars to spend in 2007. It was difficult as usual, but at the end we got what we wanted. There was a question that was raised, probably by Dr. Al-Suwaiyel, asking if we have enough resources to carry out a program of this size – given that over five years, we are looking anywhere between 60 to 100 billion dollars of projects that Saudi Aramco would be doing.

After finishing that meeting, I was taking my stroll at Lake Geneva and the Minister is calling me. I was about to tell him what happened in the meeting. He said, by the way I have a new job for you – you are going to build the new University. The King has just said that Saudi Aramco will build the University. I told him about the problems of resources that we have, but then I said, well, it is all civil work and we know how to construct buildings.

When I returned to work and after we were presented with the idea of the university, we assembled the team. We said, okay, you have a construction job and you know how to build buildings. But things started to dawn on us little by little, and we found that we did not know what to build for. That is when we started to really seek the help of the people who know the business. I am glad to say that we were blessed.

The discussions today were the most exciting panel discussions I have ever sat in during my whole life. And I have sat in many, many around the world. These are the most stimulating panel discussions, truly, I have ever heard. Normally in the afternoon, you are not awake after lunch. But I am awake and I am sure that everybody is awake.

Of course, we have shown that we have daunting challenges ahead of us. While the discussions were stimulating, they are actually scary in a sense. However, what gives me comfort is that by all of you coming from the four corners of the world, this spirit of camaraderie that you have exhibited today, the lessons that you have learned, and the mistakes that you want us to avoid, we feel comfortable that in this long road, this long ladder of which we are only at the early rungs. I feel that with your assistance, with your presence, and with your counsel, we will be able to achieve our objectives. I really thank you for taking the time to come and be with us because this is humanity for excellence.

Thank you very much.



Dr. Frank H.T. Rhodes
President Emeritus, Cornell University
Ithaca, New York, USA

Concluding Remarks

Mr. Chairman, ladies and gentleman, I realize that I am only thing standing between you and the airport. I promise to be brief. It is said that one must wait until the evening to see how splendid the day has been, and this has been a splendid day. Yesterday on the way to the KAUST campus, I saw a poster beside the road. A big banner said KAUST, the place where hope becomes reality. Today, there have been discussions on how to turn hope into reality. Yes, today was a celebration of hope, of inspiration, of groundbreaking, and of creation. Today, in the best academic tradition, has been a day of wonderful debate, of probing questions, of doubts, of difficulties, skeptical and cautionary, but in the best academic sense, positive and contributing. Where are we today at the end of a long discussion and a wonderful set of comments and papers?

The dominant theme has been one of excitement and enthusiasm for the vision of KAUST itself, of admiration for the endowment, of support for the structure and concept and organization of the university, and also this note of caution that keeps on coming up in the range of questions that have been offered. Is it possible to be too wealthy? Is it possible to be so well endowed that there is not enough competition? How can you be transdisciplinary in the institutes if you are not also disciplinary? If you are international, how can you also be local? But, of course, you must be local. This will be a great tree of knowledge, a great community, and every great tree requires deep local roots. How can you have freedom which is so critical to scholarship and the application of knowledge? How can you recruit? How can you retain?

So, on the one hand, admiration of vision and richness of the endowment; on the other hand, caution for the difficulties ahead. When Harry Truman was president, he developed a council of economic advisors made up of economists. The advice of the economists was always the same. When any practical proposal was brought up, the advice would be well on the one hand, but on the other hand, this is the situation.

Harry Truman once said, "I long for a one-handed economist." We do not have one-handed economists here, but we do have questions which have been asked not just by KAUST but by ten thousand other universities worldwide. They are not unknown questions, they are not unfamiliar, and they are not unimportant.

But KAUST has one unique advantage in addition to its endowment, in addition to the green field, in addition to the flexibility of the organization and curriculum, and the clarity of goals. It has unique advantage that it has you with your interest and your partnership and your commitment. How wonderful it was to hear just now from Mr. Jum'ah about his enthusiasm at Saudi Aramco for completing the task that has begun. How wonderful has been the support that we received, not just from the Custodian of the Two Holy Mosques but also from the Minister and from the staff of Mr. Jum'ah that he provided for us from Saudi Aramco. That has been critical to begin the work of developing the vision.

Continuing the work over the next two years, the recruitment of the President, the recruitment of the founding faculty, the recruitment of staff, and the recruitment of students will depend on the continuing partnerships of everyone in this room today. That's why your presence is so important and that's why the task before us is not just noble but also urgent. Marshal Laote, one of the great heroes of France, as an old man, was sitting in the garden of his estate and instructed the gardener to plant a tree in the afternoon in a certain place in his garden. The gardener complained, "That is a very slow growing tree, it will take 100 years to reach maturity." Marshal replied, "If it is slow growing, then we must plant it at once." And that is the urgency of the task before us and you, ladies and gentleman of the audience, are going to be the catalysts, the agents of change that will help those leading KAUST to transform the vision into a reality.

Thank you for your presence and support and contribution.

About KAUST

King Abdullah University of Science and Technology (KAUST) is being built in Saudi Arabia as an international, graduate-level research university dedicated to inspiring a new age of scientific achievement in the Kingdom, the region, and around the globe.

As an independent, merit-based institution, KAUST will employ many of the best practices from leading research universities and enable top researchers from around the globe and across all cultures to work together to solve challenging scientific and technological issues. The KAUST global research and education network will support diverse talents both on its campus and at other premier universities and research institutions, through collaborative research agreements, grants, and student scholarship programs.

The core campus, located on more than 36 million square meters at Thuwal, a site of great natural beauty on the Red Sea in Saudi Arabia. It is set to open in September 2009.

The president designate of KAUST is Dr. Choon Fong Shih and the provost is Dr. Fawwaz T. Ulaby.

A 21st-Century University

KAUST will support the highest standards of scholarship and world-class research and education in areas such as energy and the environment, water desalination, advanced materials, applied biosciences, and scientific computing that are important to the future of Saudi Arabia, the region and the world.

KAUST is being established with the following characteristics:

1. An independent university governed by a self-perpetuating Board of Trustees and supported by a multi-billion dollar endowment.
2. An explicit emphasis on the application of science and technology to problems of human need, social advancement, and economic development.
3. A quality of campus life, respect for diversity, and the highest standards of merit-based opportunity intended to attract students and faculty of exceptional talent of all nationalities and religious beliefs.

4. Advanced research centers as the primary organizational units of university; academic divisions with responsibility for educational activities and degree-granting programs.
5. Granting only graduate degrees (Ph.D's and Master's degrees) with applied research training as a major element in the degrees granted.
6. Close ties with industry, visiting corporate research programs, and an adjacent innovation center and research and technology park to link the activities of KAUST with private-sector research and economic development.
7. Substantial external research funding and collaborative educational programs to involve KAUST faculty and students closely and directly with first-rank institutions around the world in areas related to KAUST's mission.
8. A commitment to work productively with other educational institutions in Saudi Arabia and to play a role in setting new, world-class standards for academic excellence in the Kingdom.
9. A world-class faculty that will work with University leadership to guide KAUST's development, and a high-quality, international student body.
10. A campus designed and constructed for low environmental impact, with an emphasis on energy efficiency, sustainable development, and conservation of historical/cultural sites and sensitive ecosystems.

Academic Model

A modern research university is an enterprise unlike any other organization. It is organic and non-hierarchical, at least in the traditional sense. It responds to ideas and not orders from senior leadership. It relies on the free exchange of ideas. Physical and human networks – operating largely without regard for organizational or national boundaries – are a critical vehicle for this exchange of ideas and the development of new knowledge. Collaborative teams, both closely co-located and dispersed around the globe, are responsible for most research breakthroughs and their application to human needs. A commitment to excellence and collegiality is what the world's great universities strive for.

Most of the world's research universities evolved out of undergraduate institutions and are organized around Schools and Departments for teaching and mentoring undergraduates. They constantly work around these structures, however, in fulfilling their research mission, because the questions that drive scientific research do not follow the boundaries of schools, departments, and disciplines.

KAUST has the advantage of starting from scratch and will offer only graduate degrees. The research agenda will provide the foundation for the Master's and Ph.D. levels of education.

The fundamental organizing unit of KAUST will not be Schools or Departments, but research Centers and academic Divisions focused on areas of science and technology that are important to Saudi Arabia, the region, and the world. The research that KAUST conducts in the Centers will be developed in collaboration with industry from the start in many instances, in order to stimulate economic development and the benefits of rapid commercialization. As members of an academic Division, the faculty will teach Master's courses, supervise Ph.D. candidates, and participate in Boards of Study that set the program requirements and standards for the degrees that KAUST will offer.

For more information about KAUST, visit our web site at HYPERLINK "<http://www.kaust.edu.sa/>"www.kaust.edu.sa.

KAUST Symposium manuscript edited by: Dr. Earl Ernest Guile













"This symposium marks the moment when KAUST assumes its role as a convener of great minds and generator of debate, a role that is central to the mission of all great universities, and one that KAUST aspires to fulfill."

- His Excellency Ali I. Al-Naimi (Minister of Petroleum and Mineral Resources, Saudi Arabia)

"Great universities seek to understand the past, engage the present, and shape the future. Universities that have a strong focus on science and technology have a particular responsibility to engage the present and shape the future, but they too must understand the past and learn its lessons. They must do so in order to clearly understand that they are at the core of the flow of human history and essential to human progress."

- Charles Vest (President Emeritus, Massachusetts Institute of Technology)

"The university as a community of scholars had its foreshadowing in early Islamic contributions because the House of Wisdom, the Bayt-Al Hikma, was in many ways an antecedent of a university community. Around the leading mosques from the 8th to 14th centuries were assembled scholars, not only from within the nations of the Muslim world, but also from other lands."

- Frank Rhodes (President Emeritus, Cornell University)

"The goal of KAUST is as simple as it is ambitious. It is to create here a new, independent, generously funded international community of men and women, open to individuals from all over the world from different backgrounds and from different faiths. These individuals will devote themselves to the pursuit of knowledge and its application to human needs. These needs are not only for the Kingdom of Saudi Arabia or our region, important as they are, but are also the needs of the larger world."

-Nadhmi Al-Nasr (Interim President, KAUST)

"The discussions today were the most exciting panel discussions I have ever sat in during my whole life. And I have sat in many, many around the world."

- Abdallah Ju'mah (Chairman and CEO, Saudi Aramco)