

Eminent Chancellor Cuthbertson, President Weingarten, distinguished guests, fellow graduates, ladies and gentlemen, it is a great honour to become part of the distinguished community of individuals who have received degrees from the University of Calgary. I am sincerely grateful for that honour.

It is also a special honour for me to have the opportunity to address the women and men from the Faculties of Science and Graduate Studies, whose scientific expertise and knowledge are about to be formally recognized by the granting of a degree from the University of Calgary. I offer each one of you my sincere congratulations, and my best wishes as you set out to apply your talents in our rapidly changing world.

In my address this afternoon, I would like to share with you some thoughts about the present challenges and the emerging opportunities that our rapidly changing world presents for you. I offer two take-home messages.

The first is: now that your qualifications as scientists have been established, your scientific expertise and knowledge are needed to help find innovative scientific answers and solutions for the challenges we all face because of rapid growth in the human population, and increasingly rapid technological, economic and social changes in our global society, especially the challenges presented by the associated deterioration and disruptions of our fragile human habitat --- a vanishingly thin near surface layer on our lonely Blue Planet --- Spaceship Earth.

The second message is that as you leave your university studies, in the midst of a global recession, extraordinary, new and unexpected opportunities for your participation in innovative scientific and technological developments and applications are emerging because of that global recession. The impact of the recession has expanded the commitment from the Obama administration to transform

American science and innovation with unparalleled, large, long-term investments in scientific knowledge and expertise, and in science education. These investments set an example that will affect international science, including Canadian science.

We live in a time of accelerating global change --- change that is rooted in the unprecedented growth in the human population and in the per capita consumption of energy, mineral, freshwater, agricultural and ecological resources. In 1955, when I received my B.Sc., the human population on Spaceship Earth was ~2.8 billion. By ~1995, before I retired from teaching, it doubled to more than 5.6 billion. It is now about 7.0 billion. According to the U.N. Commission on Population and Development, the rate of growth has been decreasing since it reached its highest level (2.04% per year) in the late 1960's; but nevertheless, the total population can be expected to continue to increase --- to 8 billion in 2028, and 9 billion in 2054 --- before stabilizing at just above 10 billion after 2200.

The rapid growth in the human population has been accompanied by a corresponding growth in the per capita demand for natural resources, particularly food, energy, mineral, freshwater, and ecological resources. Think about the changes in per capita consumption of energy resources by residents in your home area --- starting with the years just before the arrival of the first Europeans, and continuing at multiple-year intervals to include the arrival of the first European settlers, the introduction of wood-burning steam power, railroads, the use of coal, the onset of urban and then rural electrification, use of petroleum and internal combustion vehicles, natural gas, highway transport services, and air transport, and concluding with your own annual present-day direct and indirect personal energy consumption -- including the energy that is required to produce and transport all the things that you buy as well as the energy required to meet your transportation, heating and electrical power needs, at home and at work. This kind of analysis leads to the

conclusion that the per capita growth in consumption of food, energy, mineral, water, and ecological resources in Canada and other developed countries, has probably been of the same order of magnitude as the growth in the global population; and furthermore that this growth in per capita resource consumption amplifies substantially the effects of growth in the human population. Now that globalization is making it feasible for people in the very populous developing countries, like China and India, to aspire to the same levels of profligate consumption of resources that are well established in many of the developed countries. What do you think will be the consequences of many, many more people consuming resources the way we have been doing?

Energy, mineral, freshwater, and most food resources are geographically restricted and unequally distributed among nations, and also within nations. Some nations and some regions are well endowed and can export what they do not require; others must import part or all of what they require. Ecological resources are different. They provide the ecological goods and services that are generated by healthy ecosystems and are beneficial to humans and all other living things. These goods and services include purification of air and water, decomposition and dispersion of wastes, maintenance of biodiversity, and overall maintenance of a sustainable global habitat for human life on Earth. The global oceans and Earth's atmosphere are good examples of ecological resources that are held in common, as a birthright, by all human beings. No one group has right of ownership and control over them; and everyone is responsible for ensuring that they are sustainable. However, both the shared ownership and the shared responsibility are commonly overlooked.

Growth in per capita consumption of resources within a burgeoning human population is adversely affecting our global ecological resources, and thereby, the people who depend on them. Carbon pollution, mainly as gaseous emissions from the use of fossil fuels, has emerged as the most important culprit. Abnormally high accumulations of carbon dioxide and methane that are accumulating

rapidly in the global atmosphere are already causing abnormal global climate warming as well as ecologically harmful global acidification of the oceans. These effects will continue for some time after the emissions have stopped. In June 2008, the presidents of the Academies of Science of the G8 + 5 (Canada-France-Germany-Italy-Japan-Russia-the United Kingdom and the U.S.A) + (Brazil-China-India-Mexico and South Africa) signed a joint statement calling on world leaders to implement an accelerated transition to a low-carbon society in order to limit the threat of global change. The Joint Academies of Sciences represent the leading scientists of those 13 countries.

With this brief overview of some of the global change challenges that merit your attention, let us turn our attention to some important emerging opportunities for meeting these challenges.

A transformational scientific renaissance is underway in the U.S.A. It was described by President Barack Obama, on April 27th, 2009, in his address on: “**Science and Innovation**”, presented at the 146th Annual Meeting of the National Academy of Sciences in Washington, D.C. The public policy statements presented in this address will have enormous impact on the entire global scientific enterprise, including Canadian science. They will, in my opinion, become even more of an historical landmark than President John Kennedy’s 1961 declaration that the United States would overtake the Soviet Union in the space race by sending a man to the moon and returning him safely to the Earth.

President Obama said: QUOTE ***“I’m here today to set this goal: We will devote more than 3 percent of our GDP to research and development. We will not just meet, but we will exceed the level achieved at the height of the space race --- through policies that invest in basic and applied research, create new incentives for private innovation, promote breakthroughs in energy and medicine, and improve education in math and science.”***

END QUOTE

This initiative represents the largest investment in science and innovation in American history. And it is underway now. Through the American Recovery and Reinvestment Act, the U.S. government is already providing the largest single boost to investment in basic research in American history. It has doubled the budgets of key agencies including the National Science Foundation, the National Institute of Standards and Technology and the Department of Energy's Office of Science. To those who say that in a deep recession, the U.S. cannot afford to invest in science, or that research is somehow a luxury at moments defined by necessity, President Obama's reply is: QUOTE ***"I fundamentally disagree. Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been."***

END QUOTE

While setting a goal for the United States to reduce the nation's carbon pollution by more than 80 % by 2050 (that is eight-zero percent), he said: QUOTE

"in no area will innovation be more important than in the development of new technologies to produce, use and save energy, -- which is why my administration has made an unprecedented commitment to developing a 21st century clean energy economy, and why we put a scientist in charge of the Department of Energy.

Our future on this planet depends on our willingness to address the challenge posed by carbon pollution. And our future as a nation depends on our willingness to embrace this challenge as an opportunity to lead the world in pursuit of new discovery."

"....the nation that leads the world in 21st century clean energy will be the nation that leads in the 21st century global economy."

END QUOTE

President Obama concluded his remarks by stressing the importance of international cooperation and collaboration in the pursuit of these

goals, and by urging the Academy members to join him in creative efforts to engage young people in science.

I conclude my remarks with two observations:

My fellow graduates, our dysfunctional global society needs you and your newly acquired expertise and knowledge to help it become functional again, and Barack Obama has explained to the world how your talents can be, and must be, put to work, especially during a deep recession.