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THE CHALLENGE OF THE FUTURE

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President Gee, Trustees, Distinguished Guests, Members of the Class of 1991, Ladies and Gentlemen:

Let me begin by adding my congratulations to the Class of 1991. You have worked hard and have earned the recognition that is yours today. But this is not just your day. As the parent of two college graduates, I can tell you that your parents have looked forward to this day much longer than you have. In a very real sense, this is their day, too. So let me, both personally and on behalf of all of us who are honored to be joining the Ohio State family this morning, extend to you -- parents and students alike -- our warmest congratulations and best wishes on this most important day.

As I have prepared for this day over the last few weeks -- and again when I arrived in Columbus yesterday -- I have been struck by something that all of you have probably come to take for granted, and that is the sheer, overwhelming diversity and scale of The Ohio State University. This university -- whose first graduating class, the class of 1878, consisted of just six people -- now seems to do almost everything, and to do almost everything well. From your world-class faculty and programs, to your hospitals and College of Medicine, to the Cooperative Extension Service, to the Ohio State basketball team -- whose floor I understand I'm usurping today -- everything you do seems to be accomplished with great distinction and style. In fact, President Gee told me that if my talk could even approximate the eloquence of a Jimmy Jackson jump shot, then I would be doing very well indeed.

I recognize the speakers at commencements without number have told new graduates that the future was theirs. But the situation is now different. Because the world is changing so rapidly, and because the problems facing mankind are so important, Western civilization is at a crossroads. Either your generation will build on the wave of optimism that has accompanied the events of the last few months to address the problems we face, or those problems will once again rise to defeat us and spread a mood of pessimism across the country.

We are still a young country -- a frontier country. And because of the soaring

imaginations and dedicated toil of our forefathers and their open welcome to those of other nations who have chosen to join them, we have inherited one of the greatest societies that the world has ever seen and a quality of life unmatched in the history of mankind.

The challenge of the 1990s -- and of the new millennium to follow -- is that of continuing to improve our society and our quality of life, and of making it available to those in our own country who have been passed over and to as many as possible of those in the Third World. We will do this because of our regard for the elemental rights of humanity -- but it is also in our enlightened self-interest. Unless we do it -- and are perceived to be doing it -- we will face international turmoil.

The challenge is yours. Its magnitude is enormous -- but so also are the opportunities. They, too, are yours.

The Malthusian Laws

The problems that face us can very largely be summed up in two laws. The first of these was published early in the nineteenth century by the british philosopher Robert Malthus. The second, I am confident, would have been enunciated by him had he lived to our day, so let me be generous and call these the First and Second Malthusian laws:

1. Resources are limited, and unless controlled, populations will always grow beyond the resources needed to support them.

2. Man's ability to cope with information is limited, and if unable to cope with the explosive growth in information and complexity, people become alienated and withdrawn and our interdependent society can topple of its own complexity.

These laws are entirely valid, but unlike the laws of nature, with sufficient ingenuity they can be end-run. Take the first law. What Malthus did not and could not realize is that energy is the ultimate resource. Given abundant energy, we can

have unlimited pure water by desalinating the sea. With abundant energy, we can also fix nitrogen from the atmosphere, liberate phosphorus from the rocks, and have an agriculture that will feed the world's burgeoning population. Furthermore, with abundant energy, we can recycle elements indefinitely for human use.

We have the scientific and technological ability to provide this abundant energy now, using fossil fuels and nuclear energy for the short term. In the long term, I am hopeful that we will have the energies of the sun itself -- nuclear fusion -- with which we can burn seawater to yield essentially infinite energy.

The greatest challenge we face regarding the first Malthusian law is population. In 1950, we had 2.5 billion people on our small planet. In 1980, we had 4 billion. Today we are approaching 6 billion. This is exponential growth.

Very few people have the slightest concept of what exponential change means, so let me give you an example. Suppose that I take a single sheet of paper and fold it over on itself so that the thickness is doubled. Now suppose that I repeat this process fifty times. How high will the paper stack be? The usual answer is about 12 inches, although occasionally a particularly generous one of "the Empire State Building" or "Mount Everest" comes back for shock value. What most people miss is that this is exponential growth, and that the stack of paper would thrust outward far beyond Mount Everest, far beyond the Moon, to somewhere in the orbit of the asteroid between Mars and Jupiter. Such is the power of exponential growth.

In the nineteenth century, Malthus's first law was end-run by the Industrial Revolution, which was one of the great watersheds of human development. It is important to remember, however, that the Industrial Revolution was nothing more than the application of energy, and of machines, to amplify the capabilities of man's muscles. Not only could feats of strength far exceeding man's own powers be performed, but they could also be performed over and over without boredom, without tiring, and without error.

The Industrial Revolution happened very quickly -- in less than a hundred years -- but it profoundly affected all aspects of life. It changed the quality of life, of health, of religion, of politics, and even of human birth and death. Once started it could not have been stopped or deflected; and during its course almost no one

recognized what was happening.

The question facing us today is whether an analogue to the Industrial Revolution can end-run the prospect of a continued and massive increase in the world's population. It will be a race between the development of the science and technologies needed to feed and provide for that population and the inexorable increase of human numbers. Your generation is the one that will determine the outcome of that race.

The Computer Revolution

As an example of the technologies that will be needed, let me turn to my second "Malthusian" law -- that our ability to cope with information is limited. Here again a revolution, the Computer Revolution, is under way. It, too, will happen quickly, it cannot be stopped or deflected, and although few recognize what is happening, it, too, will profoundly affect the quality of our lives.

In the case of the Computer Revolution, we are again using energy and machines, but this time to amplify the capabilities of the human mind. Not only can feats of calculation and information handling, sorting, and retrieval far exceeding human powers be performed, but they, too, can be performed at speeds millions of times faster, without fatigue and boredom, and without error.

Progress in this field has been little short of fantastic. In 1960, we could put a single active electronic device on a chip of silicon a few millimeters in diameter. In 1970, we could put a thousand devices on such a chip. In 1980, the number is one million, and the number is now around a billion.

To put this in better perspective, if the U.S. automobile industry had witnessed the same changes as the U.S. semiconductor electronics industry, a 1990 Cadillac would not cost about 10 cents, it would easily achieve 10 million miles per gallon, and it would be unconditionally guaranteed for at least 10 hundred billion miles. Unhappily, 20 of them would fit comfortably on the head of a pin!

The Computer Revolution is just beginning, but it, too, is moving very rapidly.

The human brain, to provide an example, can handle about 10 thousand billion bits of information -- though it rarely does! To duplicate this capacity in 1960 would have required a computer that would have occupied a cube one-third of a mile on a side, would have consumed as much power as New York City, and would have melted the second it was turned on. By about 2040, assuming an extrapolation of current trends, it will be possible to duplicate the capacity of the human brain in a volume smaller than the brain's and power it from the biological power sources now available in each of us.

The day when our descendants discover that their toaster is smarter than they are will mark social change with a vengeance.

Your university is now at the forefront of the Computer Revolution through your Ohio Supercomputer Center; in fact, the center was set up entirely with state funds guided by the vision of individuals here in Ohio who recognized the vital importance of this technology.

The budget that President Bush sent to Congress last month includes a special Presidential initiative in high performance computing and communications. The overall goals of the initiative are symbolized by a set of what are called "grand challenges," problems of important scientific and social value whose solution could be advanced by applying high performance computing techniques and resources. They include global climate modeling, mapping the human genome, understanding the nature of new materials, problems applicable to national security needs, and the design of ever more sophisticated computers.

What is interesting to me is that many of these problems have already been studied extensively in the Ohio Supercomputer Center. We in the federal government will therefore be looking at your experience and guidance in establishing our own program. Similarly, the National Research and Education Network envisioned under the federal program is a nationwide analogue of the Ohio Academic Resources Network, which has been a central element in your center's rapid growth.

I personally believe that high performance computing and communications could have the kind of catalytic effect on our society, companies, and universities that the telephone system has had during the twentieth century. Particularly in the area

of education, the successful implementation of this program could bring changes that are essential to the future prosperity of this nation.

Educational Reform

I mention this area of education, because I believe that it is one of the greatest challenges -- and, at the same time, one of the greatest opportunities -- that we face. I am on record as believing that the United States still sets the pace and style for the whole world in graduate education. In fact, the foreign students who come to this country to study and then return home constitutes one of America's most valuable exports.

At the college level, although our quality variations are more extreme than elsewhere in the developed world, we remain competitive.

At the precollege level, however, we have fallen far behind our international competitors. If we cannot educate our young people properly, scientific and technological supremacy will inevitably pass from the United States to other countries.

The importance of science and technology is apparent in the National Education Goals established by the President and the nation's Governors last year. Of the six goals, three directly involve science and technology, including the most ambitious of the six, that American students be first in the world in science and technology by the year 2000.

We in the Administration realize that this, among all the goals, is the stretch goal. But we feel that it was very important to establish that goal, and it is driving a number of important reforms in education.

For one thing, an interagency committee under Secretary of Energy James Watkins has been taking a close look at the federal government's efforts in science and mathematics education and has been organizing those efforts into an integrated, government-wide program. In their recently released report, entitled "By the Year 2000: First in the World," the committee lays out strategic priorities designed to meet the educational needs of the country in this area. For example, at the precollege

level, which the report identifies as the highest priority for action, the greatest need is to increase the supply of well-trained science and mathematics teachers.

These federal efforts are important, but of course the federal government cannot achieve the National Education Goals by itself. It will take all sectors of society working together -- with the goals as a consensual statement of where we are headed -- to make the kind of progress they envision.

This is where your own university is again leading the way. Through programs like your Young Scholars Program, you are reaching out to all levels of the educational system -- and to groups that have traditionally been underrepresented in our nation's college and universities. Your efforts are truly models for the rest of the country, as we seek to prepare all of our children for the challenges of the future.

Conclusion

Many of you may be thinking that there is nothing that you, as individuals, can do about the problems and issues that I have been discussing today. You could not be more wrong. Your generation is the critical one. Your generation will rekindle pride in being a citizen of this great country, will rebuild our economic and technological strengths, and will strengthen U.S. leadership in the world -- so that all of us can hold our heads a little higher.

If you fail, we may never get another chance. But I am convinced that you will not fail. Each of you can and will make a difference in whatever you do. And it bears emphasis that this is <u>still</u> the only country in the entire world where there are no artificial limitations on what you can do, what you can become, and how far you can go.

I want to conclude with a passage from a paper that H.G. Wells published in 1902, in an article entitled "The Discovery of the Future." He wrote: "It is possible to believe that all the past is but the beginning of a beginning, and that all that is and has been is but the twilight of the dawn. It is possible to believe that all the human mind has ever accomplished is but the dream before the awakening. . . . All this

world is heavy with the promise of greater things, and a day will come, one day in the unending succession of days, when beings, beings who are now latent in our thoughts and hidden in our loins, shall stand upon this earth as one stands upon a footstool, and shall laugh and reach out their hands amidst the stars."

It is essential that we not lose sight of this vision from the opening of this century as the century now comes to a close. These are the beliefs that we will need to deal with today's problems. They are problems that will demand all our vision, all our skills, all our wisdom, and all our experience, and only by working together can we hope to survive. But I, for one, remain optimistic about the outcome.

On behalf of those of us whom you may feel have received our Ohio State degrees today with considerably less work than was required of you, let me only say how honored and privileged we are to be able to join this very select group -- The Ohio State University Class of 1991.