PRESIDENTIAL ADDRESS

PAST, PRESENT AND FUTURE

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INTRODUCTION

Historians often tell us that we can obtain a better perspective of the present by looking at the past. Geologists, paleontologists, and cosmologists may have the advantage of perspective when viewing our current situation. As a paleobotanist I will attempt to include some relevant geological and biological points about the past and the present and then use these points to help focus on the future. Obviously, in this format it is unrealistic to be able to comprehensively discuss any aspect of the past, present or future. I have chosen to use a logarithmic time scale to deal with the past, and have selfishly selected only material about which I have some interest or knowledge.

THE PAST

If we arbitrarily choose ten billion years before the present as a starting point, we start when the universe was already two to five billion years old. There was no Earth, and no solar system. There was no South Dakota Academy of Science.

At one billion years before the present, Earth has been formed for approximately 3.5 billion years. There has been prokaryotic life on Earth for about 2.5 billion years, and eukaryotic cells have been present for roughly 0.5 billion years.

By one hundred million years before the present, we have had multicellular animals present on Earth for nearly 600 million years. Plants and animals have been on land for about 300 million years. The great coal fields of the eastern U.S. and Europe were being deposited 200 million years before this time. Dinosaurs have been around for well over 100 million years, and flowering plants have been alive for about 25 million years. Western coal fields and many of the major petroleum producing formations are being laid down at this time.

At only ten million years before the present, dinosaurs have been extinct for over 50 million years. The Rocky Mountains have uplifted, as well as the region from the Sierras to the Mississippi River (Ruddiman and Kutzbach, 1989). This uplift was probably accompanied by an increased rate of removal of CO_2 from the atmosphere which reduced the ability of the atmosphere to retain heat (Raymo et al., 1988). The role of mammals in the ecosystem has been established, and the grasslands are expanding in the Great Plains of North America (Thomasson, 1979).

By one million years before the present, we were in the depths of the Pleistocene glacial cycle. The genus *Homo* was well established. It is likely that fire using traditional fuels was utilized by *Homo erectus*. There was still no South Dakota Academy of Science.

At 100,000 years before the present, glaciation was continuing, and *Homo sapiens* were well established. Only 10,000 years before the present, agriculture was beginning in the Middle East. South Dakota was emerging from glaciation, grasslands were reestablished and *Homo sapiens* were hunting in South Dakota (Hannus, 1985).

One thousand years before the present, the Middle East was ruled by four Arab dynasties and one Kurdish dynasty. The Sung dynasty in China began the advent of modernity in government, society, literature, and art. Printing allowed a relatively rapid diffusion of knowledge. In Mexico and Central America the Mayas had developed the concept of zero, produced a calendar more accurate than the Julian calendar, and developed a high level of agriculture. Eric the Red discovered Greenland, and Leif Ericsson in about 1000 AD was driven by a storm to the shores of North America (Langer, 1968). Incidental use of fossil fuels was recorded by the Sumarians and Persians. The Chinese had been using coal for about 1000 years.

About one hundred years before the present, South Dakota had already been a state for two years. A news report in England indicated that the Channel Tunnel would be a reality soon. The first coin pay phone was installed. There was much legal discussion about patenting new varieties of fruits and vegetables. The first execution by electric chair took place. It was predicted that electric locomotives would soon move trains at 150 mile per hour. Darwin's (1859) *Origin of Species by Natural Selection* was already 32 years old. With the industrial revolution there was a need for different fuels and lubricants. This need led to the first commercial oil well in 1859. There was no South Dakota Academy of Science.

At ten years before the present, nuclear weapons, television, computers, aircraft, space ships, lunar landers had all been developed. On March 30 of 1981 John Hinkley shot both James Brady and Ronald Reagan. Half the people polled said that schools were doing a "poor to fair" job of educating the youth of America. The first space

shuttle, *Columbia*, was launched. The South Dakota Academy of Science was 66 years old.

In April of 1990 *Newsweek* proclaimed that science was "not just for nerds." Iraqi agents were caught trying to purchase nuclear bomb triggers. The Hubble telescope was launched. The twentieth anniversary of the original Earth Day was celebrated. It was the warmest year on record since 1859, when recording began.

THE PRESENT AND FUTURE

It is nearly impossible to discuss the present and the future separately. In attempting to prepare this talk I noticed a continual change of the future into the present and the present into the past. I have divided the following discussion of present and future into three parts, Education and Research, the Environment, and Energy. All three are closely interrelated, and I strongly believe that these three areas will become increasingly important in both the short term and long term future.

Education and Research

By most standards, the U.S. lags badly behind other more developed countries in scientific knowledge among its younger citizens (Byrne, 1989). John Miller of Northern Illinois University, in a study of scientific literacy found that only 6% of the American public can be called scientifically literate.

The percent of science classes using "hands-on" laboratory exercises is the lowest in recent times, having dropped 15-27% (dependent on grade) in the public schools. Fewer than half of the seventh grade teachers have access to a general science laboratory.

Many parents, elementary school teachers and members of the media, and the general public convey the attitude that science is tedious, difficult, or dull. Science, according to the children influenced by these people, is memorizing facts from books.

In an attempt to remedy the ills of science education, Rutherford and Ahlgren (1990) have in their book *Science for All Americans* drawn up a set of recommendations for all citizens of this country. While I'm not sure I agree with everything in the book, it is a good start, and should be on the reading list of everyone in science education at any level.

Research and development both seem to be areas that need improvement in the U.S. infrastructure. For the last forty years this country has been the undisputed leader in research. While I do not believe we need to worry about research for the glory of nationalism, perhaps we need to be concerned about our economy and the well-being of the citizens. The ability of this country to do developmental work from basic research has been severely challenged in the last two decades.

The recent war in the Persian Gulf has revealed an irony and perhaps a problem in our research and technology. The performance of the high tech weapons (admittedly against a third world nation) has raised the question of the lagging development and economic performance in high tech products. The large investment in military research and development greatly outstrips the investment in non-military research and development. There is concern about the health of the U.S. electronics and high technology industries now, as there was about the steel and auto industries in the last 20 years. For the first time in 1986, the U.S. imported more high-tech manufactured products than it exported. The three corporations registering the most patents in the U.S. last year were Canon, Toshiba and Hitachi.

Nobel Laureate Leon Lederman in his report to the American Association for the Advancement of Science (AAAS) (Lederman, 1991) pointed out the funding in real dollars has risen about 20% in the last 21 years. The number of researchers applying for those funds has doubled, leading to intense competition for those dollars. Lederman (1991) also pointed out the discouragement expressed by many of the leading researchers and their students. The results of his survey were startling to say the least. The top people in the profession were suffering from discouragement, frustration, and a gloomy vision of the future. Obtaining research funding occupies an inordinate amount of time. As funds for research increase slowly, the complexity of research has gone up tremendously. The average grant in constant dollars has actually decreased in the last decade.

Every area is short of funds. Why should science be supported more than other areas? One argument could be made for the return on investment. Science pays. Edwin Mansfield of the University of Pennsylvania has calculated that the annual rate of return on our national investment in science is 28%!

Lederman (1991) further indicated that we call on science to provide the basis for new industry; improve the general health of the population, while containing the costs of health care; understand ecological and environmental issues including guidance to policy makers; develop alternate sources of energy; enhance our culture by expanding our understanding of the universe and humanity's place in it.

The number of jobs for scientists and engineers should grow at about double the rate of the non-science job market in the 1990s (Pool, 1990). One of the concerns for the future will be supplying those

scientists and engineers. Richard Atkinson, chancellor of the University of California, San Diego, in his presidential address to the AAAS has predicted that there may be a shortage of 150,000 Ph.D.s between 1995 and 2010. This problem is exacerbated by an increase in retiring faculty and a predicted increase in student enrollments as children of baby boomers reach college age in that time period.

Environment

Last week William Reilly, head of the Environmental Protection Agency (EPA), reported an ozone decrease over the U.S. of 4-5% in the last 12 years. Higher latitudes showed an 8% loss. This is in spite of the 1987 Montreal agreement to decrease the use of chlorofluorocarbons (CFCs). The 5% decrease is expected to cause 4,000 more skin cancer deaths per year in the U.S. alone. Worse yet, the ozone loss is expected to be greater than 10-12% over the next 20 years.

The putative greenhouse gases, including carbon dioxide, are increasing in our atmosphere. Carbon dioxide concentrations have been monitored in Hawaii at an altitude of 11,000 feet since 1957. The concentration of CO_2 has continually increased since monitoring began. From other sites, the recorded change in the last 100 years has gone from 290 ppm to 352 ppm.

The seven warmest years of the century have been in the last decade. According to the Goddard Institute for Space Studies, the global average for 1990 was 0.8 F warmer than the 1951-1980 average, and over one degree warmer than the average from the 1880s. Global temperatures have risen faster since the 1960s than at any other time. This may be no more than a natural fluctuation in the climate, but it has created a scientific and political controversy. Is the greenhouse effect upon us?

At the present time we do not know how many species of living things are present on Earth. Terry Erwin of the Smithsonian Institution has estimated, based upon his studies of insects in the tropics, that there are approximately 5 million species of beetles, and 30 million species of insects. (He found over 3500 species in one tree.) Unfortunately, this diversity is in danger.

The rainforests, home to the highest species diversity on Earth, are disappearing at a rate of about one acre per second, or 100,000 square miles per year. In fact, about 10% of the global atmospheric pollution comes from burning Amazonia. At any one time there are 6,000-7,000 fires visible by satellite. At that rate, the forests will be gone by 2040. There are only about 1500 scientists qualified to work in tropical biology at this time. Even with 10X as many scientists working, it will take 400 years merely to catalog the species present. We have only about 50 years to do the job. We are currently losing an estimated two to four species per day from the face of the planet, and the rate is accelerating.

We are now beginning to understand the potential of biotechnology and the movement of genes from one species to another. At the same time, we are destroying the habitat of untold numbers of useful organisms and the habitat which houses the remaining wild relatives of our crop plants. It seems ironic that now, when we have finally acquired the technology to "splice genes," we are running out of the raw materials which could make the process so useful.

The March 29, 1991, issue of *Science* included an article about the Rapid Assessment Program (Roberts, 1991). It has become obvious that traditional research methods cannot adequately inventory much of the species diversity in tropical areas. RAP consists of a team of four biologists who are doing quick and dirty surveys of critical areas. They propose to rank the areas in terms of biological richness. While not everyone agrees with their methods, or their conclusions, the existence of the group, and the $750,000 start up grant are very real indicators of global environmental trouble.

There is some good news from the Amazonian rainforests. There was a 15% decrease in cutting from 1988 to 1989, and a 27% decrease in cutting from 1989 to 1990. This may be due to a decrease in subsidized cutting for the establishment of grazing and closer monitoring of illegal cutting. This desired result may also be due to a major recession in Brazil combined with two years of abnormally heavy rainfall, making cutting much more difficult.

Energy

World energy consumption is expected to increase 50-60% in the next 50 years. If energy sources do not change, CO_2 emissions will also increase by the same amount. One of the problems involves the established infrastructure. Public policy must include planning as well as crisis management. The energy production system does not allow rapid response. Power plants planned several years ago and now under construction will influence the way power is supplied for years to come.

Developing nations will be the site of 90% of the population expansion. Presently people in developing nations consume only about the equivalent of one barrel of oil per year. Those in Europe and Japan 10-30 barrels per year while in the U.S. we consume about 40 barrels per person per year.

In the February 1991 announcement of the National Energy Strategy program, the Bush administration reemphasized the idea that the current energy policy is to provide energy at the lowest possible cost to consumers regardless of the consequences. There were no timetables to control CO_2 emissions. The program relies on opening the Arctic National Wildlife Refuge to oil drilling. There were no programs to cut greenhouse gases, nor to decrease our dependency on oil from the Persian Gulf. There was an increase in the budget for alternate energy research of only about 1.5%. Almost no mention was made of conservation and renewable resources.

By the year 2000, many of the old fossil fuel power plants will need major modifications or complete replacement. Greg Rueger, general manager of Pacific Gas and Electric says that the new third generation of wind turbines can nearly match fossil fuel prices. Now estimated generation costs are 8-10 cents per kwh. If more demand can be generated for wind turbines, to lower the cost per unit, prices would be about 5.5-6.5 cents per kwh as compared with about 7 cents per kwh for fossil fuel plants. The greatest current problem for renewable power seems to be government officials who still are tied to fossil fuels (Dillin, 1991).

Europe and Japan are actively researching and developing renewable energy systems. Germany, Italy and Japan are already outspending the U.S. on photovoltaics and wind power. The Germans and Japanese have living standards approximately equivalent to the U.S. and achieve it on about half the energy per capita.

The U.S. imports 42% of its oil now, and will import about 65% by 2010. This is a real national security problem since 70% of the world reserves are in the Middle East, with much of the rest in the Soviet Union. The U.S. has around 3% of the oil reserves, but uses about 40% of the oil produced in the world.

Two-thirds of the energy used in the U.S. is consumed for transportation. By increasing corporate average fuel economy (CAFE) standards to 40 mpg we would reduce imported oil by 1.4 million barrels per day, the amount we now import from the Persian Gulf. Estimates of this saving actually range from 1/2 million to 2.5 million barrels per day. Over the last two years (1989 and 1990) mileage has dropped by about 1/2 mile per gallon.

No one seems to agree at just what a barrel of oil costs. Environmentalists point out that current fossil fuel costs do not reflect real costs of environmental degradation, health expenses, military expenditures, and tax credits. Hidden costs in the U.S. alone are estimated at about $100-300 billion per year. A number of states such as California, Wisconsin and New York have already begun to include environmental costs by taxes on energy.

John Gibbons, director of the Office of Technology Assessment has recently pointed out the need to address economic health, environmental quality, and national security. His conclusion was that major changes must be made which will require decades of work. He projected that a 2% increase in energy efficiency is realistic. A one cent tax per gallon of gas would raise $1 billion per year.

WHAT WE CAN DO NOW

Let us briefly summarize our present position. After 4.5 billion years of Earth's history and after 3.5 billion years of life on Earth:

1) We have a general public who know little about science.

2) We are using up the labor of hundreds of millions of years of photosynthetic organisms in 100-200 years.

3) We are releasing CO_2 and CFCs and many other substances into the atmosphere at tremendous rates, either not knowing the effects, or knowing of the negative effects of our actions.

4) We are cutting the forests which have the potential to provide genetic resources and improve the quality of the atmosphere.

In spite of our accumulating and compounding problems, we are not funding the research, or implementing the programs to provide the solutions to these problems.

What are the solutions? They are related and inseparable from science and education. I see three groups to target in our campaign to educate the public about science.

Students in our schools worldwide must have a better education in science. The Bush administration Task Force on Education has stated as a goal that U.S. students will be first in the world in mathematics and science achievement.

That the general public has a science literacy problem is well documented. We must educate them to the important aspects of conservation, the environment, and the importance of science in their economic and daily lives. They need to know that funding of science and science education is worth the investment. This will be a difficult, but necessary task.

The policy makers should be the third target. It is necessary to convince them that science is essential to our nation and to the world community. Reasons which may be convincing include economics and health.

Lederman (1991) suggests a doubling in the current level (about $10 billion) of research funding for academic science with an annual increase of about 4% for inflation plus a complexity increase of about 5% per year. Can we afford such an increase? Can we afford not to fund such an increase? The Reagan administration doubled the defense budget in the early 1980s to over $300 billion. The loss of scientific research and its resultant economic benefits is perhaps a more real threat to this nation than the military threat of the 1980s.

No single group, industry, or country is responsible for education problems, energy problems or environmental problems. Thus, one group cannot clean up all the problems. We all need to cooperate. The best way to bring cooperation is through education. Now is the time we can influence the future.

I am asking you to redouble your efforts to educate students to the joy, passion, discovery, and hard work of science. I am not asking you to make science classes easier, or to include less content. I am asking you to reveal to your students the attitude that drew you to science.

I am asking you to make your opinions known to lawmakers on all levels. These people are human, and sometimes respond to logical arguments as well as more direct pressures. As a scientist/educator you may be able to exert more pressure than you realize. This is especially true if we work as a group.

I am asking you to communicate your research results where appropriate, your concerns about the future, and especially to communicate the true importance of science to the public and the media.

Ladies and gentlemen, we have a lot of work to do. Let's get started.

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