United States Department of Commerce
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National Institute of Standards and Technology

*NIST Special Publication 897*

*A Working Conference on*

# *Global Growth of Technology: Is America Prepared?*

*Sponsored by*
*Council on Competitiveness*
*and*
*National Institute of Standards and Technology*

*December 7, 1995*
*National Institute of Standards and Technology*
*Gaithersburg, MD*

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*December 7, 1995*
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# Council on Competitiveness

The Council on Competitiveness is a nonpartisan, nonprofit forum of chief executives from business, university, and labor working together to set a national action agenda to strengthen U.S. competitiveness. The Council believes that competitiveness is a compelling priority for the country as a whole because it underpins the standard of living of every American as well as U.S. leadership in the international community.

The Council actively engages its 140 members in a work program that spans technological innovation, human resource development, trade, fiscal policy, and the benchmarking of U.S. competitiveness. The Council normally focuses on two major initiatives a year. Council members select issues to examine, then form advisory committees to gather data and develop consensus-based recommendations. This approach allows the Council to combine exhaustive research with the practical insights of leaders from industry, academia, and organized labor. In addition, chief executives from more than 40 of the country's most prominent nonprofit research organizations, professional societies, and trade associations contribute their expertise as national affiliates of the Council.

The Council views its reports and recommendations as starting points to help set the national agenda on competitiveness issues. Once a report has been released, Council members follow up with press briefings, Congressional testimony, discussions at the highest levels of the executive branch, and meetings across the country. The work of the Council is guided by a 25-member Executive Committee. A full-time staff of 16 provides research support and operational outreach.

# Publications

***Endless Frontier, Limited Resources: U.S. R&D Policy for Competitiveness***

The report examines research and development trends in the six key industry sectors, provides policy guidelines to meet the challenges confronting the stakeholders in America's R&D enterprise, and sets the agenda for a national discussion on the future of R&D by focusing on industry/ government/university partnerships. April 1996 ($25.00; $3.50 s/h domestic & $6.50 s/h foreign).

***1995 Competitiveness Index***

U.S. performance is compared with that of other Summit 7 countries in this annual assessment of America's competitive position. The Index addresses four key areas: investment, productivity, trade and standard of living. August 1995 ($15.00).

***Building on Baldrige: American Quality for the 21st Century***

This report reviews the effectiveness of and gives recommendations for the continuation and expansion of the Malcolm Baldrige Quality Award program in promoting quality principles and practices. August 1995 ($15.00).

***Human Resources Competitiveness Profile***

This report looks at a lifecycle approach to competitiveness and human resource issues in four areas: family and early childhood, primary and secondary school education, university education, and training. U.S. performance in these areas is compared with other countries. April 1995 ($15.00).

***Breaking the Barriers to the National Information Infrastructure***

The third in a series of policy documents, this report highlights the Council's September 1994 NII applications conference. It lists and examines the barriers users are facing in manufacturing, education, electronic commerce, healthcare and entertainment. December 1994. ($25.00; $3.00 s/h domestic & $6.50 foreign).

***Critical Technologies Update 1994***

An update from the Council's Gaining New Ground report, this document reevaluates America's performance in 94 critical technologies. September 1994. ($10.00).

***Economic Security: The Dollar$ and Sense of U.S. Foreign Policy***

This report analyzes eight case studies involving recent foreign policy decisions, with emphasis on export controls and export sanctions, and tallies their cost to the United States in terms of lost exports and jobs. February 1994 ($25.00).

***Vision for the 21st Information Infrastructure***

The first in a series of NII policy reports, this statement defines information infrastructure, assesses the U.S. position relative to its foreign competitors and addresses the roles of government and the private sector. May 1993 ($15.00).

***Highway to Health: Transforming U.S. Health Care in the Information Age***

A follow-on to the council's NII applications conference, this report illustrates how the NII can be harnessed in conjunction with market forces to address the need to control costs at a time when the demand for healthcare services is rising. It identifies the principle barriers preventing the development of four robust healthcare market segments—"Remote Care," "Individual Health Information and Management," "Integration of Health Information Systems," and "Healthcare Research and Education"—and recommends steps to overcoming those barriers. March 1996 ($25.00; $3.50 s/h domestic & $6.50 s/h foreign).

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# Introduction

The purpose of this conference "Global Growth of Technology: Is America Prepared?" was to articulate the issues behind the question and to address these issues from the broadest range of perspectives. The impetus for the conference was provided by the National Institute of Standards and Technology's (NIST) Visiting Committee for Advanced Technology. The Committee enlisted the support of the Council on Competitiveness (CoC) for organizing this meeting. NIST and the CoC are appropriate partners to host this conference: NIST's programs are defined by its core mission of promoting U.S. economic growth by working with industry to develop technology, measurements, and standards; the CoC focuses on the key issues related to competitiveness such as trade, productivity, investment, and the U.S. standard of living.

A select group of American leaders from industry, academia, and government attended the conference, representing business, economics, labor, education, and Federal policy perspectives. The meeting was cochaired by John Yochelson, President of the Council on Competitiveness, and Arati Prabhakar, Director of NIST. It was divided into five sessions, each consisting of a presentation followed by discussion. The first three sessions concerned the societal impact of technology including its effect on industry, workers, and the quality of life. The fourth session focused on the impact of technology on American competitiveness. The final session addressed the appropriate role of government in support of technology.

# EXECUTIVE SUMMARY

## GLOBAL GROWTH OF TECHNOLOGY: IS AMERICA PREPARED?

Dr. Robert J. Hermann discussed American technological strengths, highlighting systems and systems integration as a crucial American strength. A major point of his discussion was that technological strength was only one of several strengths needed to compete in a global economy. Other key American strengths enumerated by Dr. Hermann include military strength, entrepreneurial freedom, and moral authority.

Dr. Thomas Everhart made a second defining point for the workshop by asserting that we are shifting from an economy based on natural resources to an economy based on information and knowledge. There was an extensive discussion on how to prepare workers with appropriate skills for the new economy and how to do this in a way that benefits are evenly distributed. Economists pointed out that intellectual skills are not properly included in the return-on-investment equation even though such skills drive "information technology." In previous resource driven economy, manufacturing equipment and material processing were major cost factors. Dr. Gary Burtless presented data to demonstrate that over the past two decades, the time period during which the economy changed to one dominated by information, a widening gap has developed between the highest and lowest incomes. The problem posed by a skewed income distribution along with a stagnating standard of living was viewed as among the greatest problems facing our society. A number of suggestions for addressing this problem were presented including improved education of workers, saving and investment by the public, more involvement in the process by the information gurus such as Bill Gates and Michael Eisner, and company sponsored worker training programs such as those being developed by Motorola and Hewlett Packard.

The role of international companies in relation to the global economy was another key theme of the conference. The leaders of international companies at the meeting expressed the following far-reaching ideas: that a reduction in market share would be viewed as success, assuming a sufficiently large increase in the total market; that the companies would focus on improving all aspects of its workers' lives as well as the United States; that low employee wages were not the prime interest for a company locating a facility in a foreign country; and that a company cannot succeed unless its competitors succeed. The international companies based in the United States recognize that they must do more on behalf of their foreign workers' standard of living and rights. Companies are finding ways to resolve the apparent conflict between international business strategies and national interest.

Dr. Rita Colwell gave a vivid picture of the promise of biotechnology for improving our quality of life. However, she and Mrs. Diana MacArthur identified constraints for full realization of the evolving technology. These barriers include lack of support for biotechnology enabling research, failure of the Health Maintenance Organizations to support the health care infrastructure including academic health centers, and troubling ethical questions related to manipulating the genome and paying for health care.

Mr. Robert W. Galvin acknowledged the Constitutional mandate for partnerships between government and industry, but wasn't afraid to stir the pot by questioning whether the current government laboratories were worthy of partnerships. He proposed that Congress fund multi-year research projects in general fields defined by the private sector through depoliticized institutions with minimum government interference. Mr. Galvin predicted increasing industrial revenue will lead to a shrinking role of government in the area of semiconductor technology. He stated that mission oriented agencies appropriately should continue to sponsor mission related research and development, using national defense and standards missions as examples.

# SUMMARY

# GLOBAL GROWTH OF TECHNOLOGY: IS AMERICA PREPARED?

### Session 1: The Impact of Technology on the U.S. Ability to Compete

Speaker: Robert J. Hermann, United Technologies Corporation

Dr. Hermann began with the tough questions: What do we mean by competing and winning? How will we measure success? He identified improved quality of life as an indicator of success and this should extend to our "competitors," that is, to our trading partners and allies. He stated that it is unlikely that we can reap the benefits of a high quality of life without our "competitors" also succeeding. He went on to give an example, saying that his company makes jet engines, some of which are installed in Boeing aircraft. Neither Boeing nor United Technologies will do well in the future if the Chinese cannot afford to buy plane tickets.

Dr. Hermann presented a strategy for American participation in a world economy. He said we must recognize our strengths and build upon them. First, the fact that the United States is the only superpower colors every relationship. We are expected to lead in all aspects of life, but are resented when we do. Our political system is a key strength. It provides stability, personal freedom, and entrepreneurial freedom. Our diversity and individual freedom are enabling features of our society which will not be easily emulated elsewhere. He did point out one weakness in our economy: the large gap between the highest and lowest paid. This gap puts at risk our moral authority, political stability, and any national feeling of a superior society. This aspect of our society must be corrected.

Dr. Hermann noted that statistically we are the strongest producer in the world, world class in science and technology, have a strong manufacturing sector, and a powerful service sector. He identified systems integration as a unique advantage. The ability to integrate technical, financial, and all aspects of business will be critical. The ability to organize and coordinate multi-cultural efforts will become crucial. We have a unique, almost uncatchable position in systems.

Dr. Hermann stated that a new paradigm will be needed compared to the approach used during the cold war. Competition is taking different forms. It will depend on more than science and technology and must be coupled to our other comparative advantages. Dr. Hermann believes we can thrive in the future and participate in the advance of other societies while we do so.

Discussion:

*Standard of Living: Recent History*

One major focus of the discussion was the quality of life/standard of living. Hermann expanded on his presentation with specifics of a quality of life including individual freedom in the entrepreneurial sense and security from physical harm. The ensuing discussion focussed on the more easily characterized standard of living. There was general consensus that while the economy was continuing to grow, the standard of living had stagnated over the past 20 years. It was pointed out that there was a marked decrease in productivity growth about 20 years ago from about 2.5 percent per year to about 1 percent per year and it has stayed flat since then. The cause is not known. Concern was expressed about the income distribution problem, discussed earlier by Hermann, including the belief that this condition has been aggravated by corporate downsizing and the loss in power of the unions.

*Ideas about Improving the Standard of Living*

There was extensive discussion about how to improve standard of living and income distribution. In terms of the economy in general, there is a need for increased investment. This point was mentioned

by several people; however, it was also pointed out that this is difficult if the salaries are low. Consumption and savings need to grow together. One approach for improving income distribution was to focus on training for the less skilled. Another was to look toward corporations to address the issue of income distribution. The negative impacts of corporate downsizing, corporate buyouts, and reduced wages for lower skilled workers were categorized by one participant as "corporate misbehaving." Another felt that the challenge was to keep the positive aspects of current corporate activity while providing improvements for workers. Hermann indicated that the new wave of technologists, like Gates, need to participate more in the political process. This will help us develop a better intellectual basis for what determines our success.

*International Trade*

A third topic concerned the impact of international trade on the American standard of living. It was stated that selling low technology products to China will not solve our standard of living problem, especially if it leads to companies producing products in China based on paying low wages to the Chinese workers. It was pointed out that some of the Chinese sales were high technology such as telephone equipment. This helps the economy. Another approach to improving international trade is to risk more money with small high technology companies to take back the low technology product market at home from foreign competitors.

## Session 2: The Implications of Technology Growth for Industry

Speaker: Thomas Everhart, California Institute of Technology

The United States is in a technology-based economy. The United States has moved in the last century from a resource-based economy built on natural resources, minerals, oil, and agriculture, to an intelligence-based economy. In the future it is those processes that have value added by human minds that will grow. In a large measure, we haven't figured out the consequences of this change. And some other countries (such as Singapore) understand it better than we do. The issues of competitiveness go beyond just the bottom line for a company—which is short-sighted—and must include the entire fabric of our nation, including policy.

There are many types of change:

| | |
|---|---|
| -revolutionary: | radios to TV, piston engine to jet engine; |
| -evolutionary: | automobile; |
| -labor-saving: | washing machine and breadmaker; |
| -time-saving: | e-mail and fax, TV. |

Technological change leads to reengineering the processes in our institutions; which leads to empowering of workers. The movement is away from rule-based control to workers' judgment. For this reason, we need to invest in our workforce—to promote education and training for workers. This investment is especially hard for small companies.

The computer industry provides a telling example of revolutionary change: in the movement from vacuum tubes to transistors to integrated circuits. The leaders at the beginning are not the leaders now. The early firms could not adapt fast enough. They could not envision what the world was going to be like and how they would fit into it. Technological change requires imagination and creative vision - new systems to handle the change.

The role of education in America is critical. The universities must supply the intelligent people needed to support the information-based economy. The universities must teach people how to think. The K-12 system in America is archaic and needs to be fixed. Secondary schools need to teach students about science—how you do science, not just the content of science. As emphasized by Michael Eisner, the head of Disney, in describing the movie "Toy Story": the technology is good, but the most important thing is getting the story right. Both the story and the technology require intellectual input. That is the natural resource we need to use.

Discussion:

*Investment in Education*

How do economists include intellectual skills in the return-on-investment equation? Normally they are not included. Traditionally, education and skills are treated by the same models as physical capital, where future income is estimated from the investments made today. However, measures of education are crude—years in workforce, years of education. These measures may not reflect vital information for today's skills. It is a mistake to concentrate only on physical capital simply because it is easier to measure. We need a wiser dialogue. The errors we make in estimation of physical and educational capital are the same. We do know what we are spending on education and training. What we don't know is what we are getting for our education dollars and who is spending what on education (individuals vs. government vs. companies). We do know that the investment is going down. Tax policy does not wisely support education. For instance, training for new jobs is not tax-deductible, only for current jobs. And, no one is willing to pay taxes to support education.

*Paradigm Shifts in College Education/Where Education Fails*

The U.S. college and university system is working well and is the envy of the world. One of the

revolutionary changes is the percentage of the population that now attends college. It is the K-12 system that is education's weak point in the U.S. educational system. However, the college system in the United States is in need of change. Continuing education is crucial to continuing growth, and a paradigm shift is needed to bring the university to the student instead of the student to the university. Although there are nontraditional universities ("university of TV") already in place, there is tremendous value in attending college; the time spent in the college milieu and the social interactions that occur are as valuable to the student as the information learned. It is also true that present technological systems, videotapes and interactive computers, can and will bring education to the home, and that the Internet will be a vast resource for education in the future.

What is happening in the Nation's K-12 system reflects the Nation's failure to invest in our non-college-bound students. We have a system that does not support 16- to 25-year-olds in finding jobs with potential. Apprenticeship programs are vital. Employers in general say training is critical but then dedicate their efforts to improve training in schools. How do you get employers to buy into and to value worker education. Businesses are not rewarded for the development of and investment in human capital. And yet, investment in people underpins growth in our knowledge-based economy. Increased automation of complex processes in our society, from manufacturing to government and health care, has not happened in education. The question remains, how and when to use technology in education and how to enable the lower strata of society to deal with this knowledge-based economy. PacTel may be wiring every school in America for the Internet, but how do you use it? It is threatening to the teachers and really does require a paradigm shift in education. We have a lot to do to reengineer our processes in government, education, and industry.

## Session 3: The Implication of Technology Growth for the Workers

Speaker: Gary Burtless, Brookings Institute

Dr. Burtless focussed his talk on two issues:

What has happened to our relative wages over the past 20 years?

What has happened to the relative intensity of use of the skill classes of American workers?

Dr. Burtless used a series of graphs to summarize the information on these issues (see transcript later in this report). Between 1973 and 1993 the relative wages at the upper and lower ends of the distribution have widened greatly, especially for men, with the lowest 5 percentile earning about 30 percent less in 1993 compared to 1973. He showed there has been a precipitous change in salaries as a function of educational attainment since 1979. For example, in 1979 the salary of a person without a high school diploma was 60 percent of that of a college graduate, while in 1993 it was about 40 percent.

Some try to blame this trend of widening relative wages on international trade. Dr. Burtless showed that the earnings ratio for trade-affected industries and least-affected industries had the same trend over the past 25 years, suggesting that international trade was not a major factor. He did allow that international trade could have a second order effect by displacing workers from trade-affected industries to lower paying nonaffected industries.

Dr. Burtless then examined the classic economic factors, supply and demand, for an explanation of the increasing disparity in wages. Contrary to some people's suggestions, the supply of skilled workers as measured by education has continued to increase, though less rapidly than in the 1960's. So supply does not appear to be the issue.

The analysis of the demand side of the equation is more complex. There has been a shift in demand that favors the highest level of education. This is not a technology driven trend but rather a result of changes in how firms are managed and organized. These changes arose from the corporate buyout culture, international trade, and the emergence of the personal computer as a routine tool. The threat of corporate buyouts and the resulting focus on the bottom line has led to both a reduction in middle managers and in reduced salaries for some workers.

Dr. Burtless then addressed the central question: What factors might cause the American worker to be shortchanged? He pointed out that U.S. secondary school graduates are poorly prepared, especially relative to the Japanese and European students. There is a much greater public investment in education for the college graduate than for a student not finishing high school (approximately 4 to 1). This same trend also persists for investment in training provided by employers. In other countries the difference is smaller.

For the top one third of Americans, we are doing very well, perhaps the best in the world. On the other hand, for the remaining two thirds the system is doing poorly and we need to do better. An increased investment of both public and private funds is needed.

Discussion:

*Training for American Workers*

Several panelists gave examples of companies, including Hewlett Packard and Motorola, that seem to invest more on training the lower skill level employees than on the higher levels. One panelist indicated that there was tremendous resistance to changing the curricula of secondary students to provide higher skilled workers; however, community colleges were receptive to plans for improving workers skills. Dr. Burtless admitted that there were companies providing exceptional support to the less skilled employee, but he reiterated that surveys indicated the opposite on the average; that employers invest the most per capita in continued training in their most highly skilled employees.

*Mobility of American Workforce*

A need was identified for institutional support for the increasingly mobile American workforce - such things as portable pensions and health care. As a result of corporate takeovers, the likelihood of an employee's staying 40 years at one company was now small. Dr. Burtless replied that, on the average, an employee's tenure with a company was as long or longer now than previously, except for the least skilled worker. However, he pointed out that the penalty for losing a job is greater than in the past.

*Reducing Wage Disparity*

There was interest in the possibility of a supply side solution to the problem of wage disparity via improved training and education. Dr. Burtless indicated that an improvement in the skill level would increase the wages to some extent, but there is more to the problem than the supply of skilled workers. He stated that there were other institutions within the society which ensure the persistence of wide wage disparities.

Dr. Burtless referred to his book entitled "Growth with Equity" in responding to how the disparity in wages might be changed.

Two specific recommendations are an investment in lower skilled
workers and the establishment of a worker's tax, which could be avoided if companies trained their own employees. Earlier it was mentioned by one of the panelists that the training tax had failed to excite serious political interest.

## Session 4: Implications of Technology Growth on the Quality of Life

Speaker: Diana MacArthur, Dynamac Corporation

One of the most important quality-of-life issues is the maintenance of the primacy of the U.S. health care system in the face of transformations caused by changes in legislation, regulation, and the marketplace. Cost considerations are causing changes that create market barriers—barriers that not only will inhibit the growth of biotechnology and other health care industries but also impede the delivery of quality health care. These changes are manifested by the growth of mega managed care organizations and the restructuring of the medical insurance industry.

These changes threaten a critical component of the U.S. health care delivery infrastructure—the academic health centers (AHCs) that train physicians, develop biomedical knowledge and clinical techniques, provide unique patient-care resources, and treat many of the indigent and the uninsured. The preservation of AHCs and their research and education roles in the evolving health care industry is a major issue in the broader weave of national security and requires policy development at the highest echelons of Federal and state governments. Development of improved systems and procedures to achieve cost reductions and increased efficacy of treatment is needed to moderate the overall cost of health care services and to allow more resources to be directed to medical research and education. The quality of health care should not be sacrificed in the name of cost containment.

Speaker: Rita Colwell, University of Maryland Biotechnology Institute

Are we prepared for what DNA sequencing will bring us? We are in the midst of a revolution—biotechnology, genome sequencing, and DNA technologies promise to revolutionize medicine. There are 108,000 employees in the biotechnology industry today. It is predicted that there will be more than a million biotech employees in 2005 or 2010. The ability to sequence the DNA of pathogens—there are now several examples of where this has been done—will result in different, more effective ways to target pathogens. The goal of sequencing the entire human genome is in sight and gene therapies have been proposed which will drastically change the nature of medical treatment. Medicine will become proactive and prophylactic rather than reactive and therapeutic. This vision may not be immediate; in the near future the greatest advances will be in diagnostics.

The biotechnology revolution will create tough social issues that must be faced. The identification of genes that predispose an individual to a specific disease state, such as cystic fibrosis or lung cancer, is information that can both be used and abused. Medical care can be provided to treat susceptibilities and behavior can be modified to minimize the potential onset of these predisposed disease states. But what is society's responsibility? What is the appropriate response of health insurance and health care providers? There are also complex ethical and economic issues to be faced. To what extent should the genome be manipulated? How are medical care resources to be allocated, and who should pay? There are no easy answers.

Biological terrorism is also a real threat and the role that biotechnology could play in weakening our national security must be considered.

The biotechnology revolution will impact more than medicine. The potential impact on agriculture is just as great. The reengineered tomato is available today and the potential for modifying future agricultural products to improve productivity and quality of these products is tremendous. Bioremediation or environmental biotechnology may also be significant. The day may come when waste streams are considered resources—to be mined by biotechnology processes—rather than the costly nuisance they are today. Environmental biotechnology is moving to the billion dollar range and is critical to addressing environmental problems while at the same time creating new industries. To achieve this vision will require the education of the public about the advantages of this technology--and its safety and efficacy.

International competitiveness in biotechnology is a serious problem. U.S. investment is not equivalent to other countries or appropriate for the United States For instance, in marine biotechnology, the Japanese have invested at least a billion dollars in the last 5 years with active involvement from industry. The United States has only invested $100 million in marine biotechnology, only $40 to $50 million by the U.S. Government. There is a major danger that we will lose momentum and the lead in this critical new technology area.

Discussion:

*Education*

We must deal with public attitudes. We must have a population educated to the point where they will accept advanced technologies. If people are entertainable, they are educable. Government must be there to help educate. It is up to universities and business organizations, those organizations that base their decisions on evidence, to lead the discussion. It is up to the leaders in this room to take charge.

*Ethics*

What are the appropriate mechanisms to deal with ethics? Public discussion, community-based, among the medical, religious, and scientific community leaders is essential. Universities have developed cross-cutting resources for studying the issues. Government and corporations should avoid talking about so-called ethical concerns since they are essentially unqualified. Such discussion invites domination by ideologues.

*Competitiveness of Biotechnology*

The competitiveness of the biotechnology industry was argued. Many people view the biotechnology industry as one of our great success stories. The United States invests a lot of money in R & D and skews its investment toward biomedical research. However, competition is fierce and we must be wary of complacency. The role of venture capital was also argued. Venture capital is not at all venturesome and may not have a long enough view. It is a problem if firms are formed with the expectation that they will be taken over rather than grown. However, it is the role of venture capital firms to avoid risk. It must be recognized that the firms receiving venture capital have higher success rates than firms generally. The U.S. venture capital market is the envy of the world and our risk capital is way ahead of our competitors.

*Barriers*

Public policy institutions that deal with biotechnology products need to be reengineered. Both regulations and tests are out-of-date. New mechanisms are needed to help the United States compete. This is not a problem of just biotechnology, but other technologies as well. Barriers to commercialization exist because of negative practices by the U.S. Government that delay time-to-market. Government can institute tax and accounting policies that will reduce risk and spur investment. The United States never seems to get any further than recommendations for change in public policy.

**Session 5: Technology and Government Policy: What Level is Appropriate?**

Speaker: Robert Galvin, Motorola, Inc.

Robert W. Galvin focussed his presentation on the question: Is there a role (in technology development) for a partnership between the federal and private sectors? He answered this question immediately as: mostly yes, citing the United States Constitution, in which our founding fathers in effect said that Congress shall have the power to promote progress in science and the useful arts. He expressed his desire for the Federal Government and Private Sector to cooperate with each other and form alliances, working together as effectively and harmoniously as possible to define "results-intended activities of mutual benefit."

Galvin stated that he sees some very significant things happening with regard to what the Private Sector profile is going to be in the next 20 years, and to demonstrate this and provoke interest he profiled his own company, which he views as not so different than others. Motorola intends that within the lifetime of its current head of the corporation (Galvin's son), 95 percent of its business will be outside of the United States. This is despite expecting a very robust American economy and anticipating Motorola's success in it. Hence, the United States cannot be viewed as the center of the (consumer) world, but rather will soon be only a 5 percent factor. Galvin also pointed out that companies like Motorola will soon be doing a lot of technology development on their own. He went through a projected growth scenario for Motorola, which would lead to around $100 billion in technological research by Motorola both in the United States and abroad by 2025. He stated that with similar growth by other firms the Private Sector's investment in technology would dwarf that made by the Federal Government.

In addition, Galvin pointed out that a factor currently hindering partnerships between the Private Sector and the Federal Government is that U.S. companies find great difficulty doing business with U.S. Government laboratories, certainly more difficulty than a U.S. company doing business in a foreign country. He asserted that if the Federal Government considered itself an entity that had to compete, there is a question as to whether in the next 5 to 15 years it would be worthy to be a so-called partner to the Private Sector.

Galvin concluded his prepared comments by reviewing a single-page handout (see transcript later in this report) giving his view of how Congress could promote science and technology. Congress should fund multi-year research and development in general fields that are defined by qualified, predominantly the Private Sector, experts, and that the projects should be roadmapped to the extent possible. Furthermore, the money should be given to depoliticized institutions established for governing and dispersing such funds, and the funds should ultimately go to the people who can most effectively spend the money. Government for the most part should then get out of the way. Congress should have the power to promote progress in science and technology applied worldwide commercially and there should not be a restriction that any (federal technology development) money spent in the United States can only be used in the United States. Finally, Galvin proposes that in this new scenario, the depoliticized governing bodies will annually account to Congress according to a new standard, using private sector financial reviews performed by public accounting firms. All other methods of auditing and review would be eliminated, in which case, Galvin asserted, the productivity of the Federal Government science and technology would go up at least double, and then maybe the Federal Government and the Private Sector could afford to be partners!

Discussion

*Challenges for International Companies*

Chief Executive Officer's of international companies based in the United States are put in a difficult position from time to time, because they are inevitably doing things that are good for their company which may be viewed by many people as not being in the in the best interest of the country. Still, it was pointed out that we have to become "internationalists" because it is the best thing for our country.

While it may seem counterintuitive, the more invested overseas in building industries and markets, the greater the exports that are created. A related point was that a key ingredient to becoming a successful alliance partner is to make your partner a success. One participant felt that it was possible to deal with the issue of loyalty to company and country as two issues. Companies' citizenship responsibilities are different than monetary responsibilities of the country. He pointed out that there should be a strong self interest in being in a strong country with a solid economy, since this will enhance the success of the company in dealing with international commerce.

*Effect of International Companies on the Standard of Living*

There was concern expressed that the increasing trend to forming international companies and the increased presence of American companies in foreign countries would adversely affect the labor market in the United States. Ultimately, the standard of living would decrease in the United States. One person stated that international trade agreements should include international labor standards, international standards of human rights, the banning of child labor, and international environmental standards so that the economic prosperity of the developing country would be shared by the workers and the people generally. He stated that the international business community needs to support the labor movement's pursuit of a decent living standard as the economies in these developing countries grow. Galvin agreed with this perspective and said that companies must serve as role models in how they treat people in the United States and abroad, though he expects that it will take some time. Just as the level of thinking about quality-related issues has improved markedly over the past decade, the United States could have a very positive impact on elevating standards of labor relations and compensation worldwide.

*R & D by Mission Oriented Agencies*

Galvin's suggestion for funding industrial research bypassed normal funding institutions. There was a question about separating the mission agencies from their R&D needs. Galvin replied that there would be exceptions to the rule and that there would be, for example, a need for a warfare center for the Navy and there should be a separate budget for standards setting.

# Appendices

The following pages contain the Agenda of the meeting, editorial transcripts, biographies of the speakers, and a list of attendees.

Appendix A. Agenda for Meeting

Appendix B. Transcript

Appendix C. Biographies of Speakers

Appendix D. List of Attendees

## A Working Conference on Global Growth of Technology: Is America Prepared?

**December 7, 1995**
**AGENDA**

Co-Chairs: Arati Prabhakar, Director, National Institute of Standards and Technology
John Yochelson, President, Council on Competitiveness

9:00 a.m. **The Impact of Technology on the U.S. Ability to Compete**

- The growth of technology industries in the Unites States and abroad
- Technology industry trends in international trade
- Is America keeping up with its competitors?

**Speaker:** Robert J. Hermann – Senior Vice President, Science and Technology, United Technologies; Chairman, Visiting Committee, NIST

10:15 a.m. **The Implications of Technology Growth for Industry**

- Fostering technology-based risk
- Investing in, and protecting, information-based infrastructure
- Committing to short-term and long-term R&D

**Speaker:** Thomas Everhart – President, California Institute of Technology

11:15 a.m. **Break**

11:30 a.m. **The Implications of Technology Growth for Workers**

- Meeting the need for new and more advanced skills
- Will the decline of mass production and the assembly line, and the growth of "craft-oriented" production, create more or different jobs?
- Empowering workers to accommodate to technology changes

**Speaker:** Gary Burtless – Senior Fellow, Brookings Institution

12:30 p.m. **Break and working lunch**

1:00 p.m. **Implications of Technology Growth on the Quality of Life**

- The impact of technology changes on health and on the environment
- Adjusting to changing life styles
- Gaining – or losing – the sense of community

**Speaker**: Diana MacArthur – Chair, CEO, and Co-founder, Dynamac Corporation; member, President's Committee of Advisors for Science and Technology

**Speaker**: Dr. Rita Colwell – President, University of Maryland Biotechnology Institute; President, American Association for the Advancement of Science

2:15 p.m. **Technology and Government Policy: What Level Is Appropriate?**

- Should government develop a partnership with the private sector to promote and accommodate to technology change – or leave it to the free market?

**Speaker:** Robert Galvin – Chairman, Executive Committee, Motorola, Inc.

3:45 p.m. **Adjourn**

# Appendix B:

## Edited Transcripts of the Meeting

### Introductory Remarks by Dr. Arati Prabhakar and Mr. John Yochelson

Opening Remarks

DR. PRABHAKAR: We are very delighted to be hosting this meeting today with the Council on Competitiveness. John Yochelson, who is the president of that organization, is here with me.

Let me start by telling you just a moment's worth of how we got to this meeting and what we hope will come out of the discussions today. The conversation that led to this meeting really began with Dr. Hermann, who is sitting to my left.

Dr. Hermann is chairman of our Visiting Committee here at NIST, a group of outside people who come in four times a year and talk with us about our programs. Most of our attention in those reviews has been focussed on the operations of our programs and how do we prepare for the future.

Our job is a component in a much larger technology system, but a component that's focussed ultimately on economic objectives—we're part of the Department of Commerce and we work on technology issues that relate to our industries and are focussed on creating opportunities downstream in an economic sense. It became very clear as we struggled to do our job that it would be extremely useful for us to take a moment, zoom our lenses back, and think about the broader context in which we are operating. We also need to think about the environment in which we're trying to do our work.

The question began with one of the imponderables, the question of how does technology relate to the standard of living in our country. That was the beginning of our discussion.

As we talked about it in our Visiting Committee, Howard Samuels, who is an active member of this committee, got engaged, proposed that we do this meeting, and has worked over the last several weeks and months with some of our folks and people at the Council on Competitiveness to draw all of you together to engage in a dialogue about the environment in which we think about technology, its role in a global marketplace, and what that means for us as a nation.

These are very broad topics. We think that there is tremendous value in exploring these questions from many different perspectives. We're delighted to have such a terrific group of
people around the table and particularly, I think, a lot of very stimulating speakers lined up for the conversations today.

Howard, very unfortunately, has an illness in his family and isn't here today. But we will proceed with the meeting in his name. And that's my brief welcome. Now I'm going to turn it over to John Yochelson.

MR. YOCHELSON: I am truly the new kid on the block. I have been at the Council on Competitiveness for four days. And I am honored, and we at the Council are honored, to join Dr. Prabhakar and NIST in this effort.

I am awfully sorry that Howard Samuel can't be here. It was indeed his brain child. He contributed so much. I was on the phone with him. He would very much liked to have been here. He's doing the best he can in a difficult situation.

I will spare you an advertisement about the Council on Competitiveness only to say that we are on the

threshold of our tenth year, bringing together leaders from industry, the university community, and labor.

It is, we hope, not an accident that during those 10 years, one colleague mentioned before we started that the word "competitiveness" is the most used word now by industry as it talks about itself in the rest of the world. So we are absolutely delighted.

## The Impact of Technology on the U.S. Ability to Compete

DR. HERMANN: We are gathered today to discuss the readiness of our society to compete with the rest of the world. While global growth of technology is a central focus of our assessment, I believe it makes the most sense to do so as a part of evaluating our broader, competitive position.

We need to understand how we are doing in specific areas of science, technology and technology related industries. But this is a difficult assessment to make. That is, how are we doing? Agreeing on what measures to use is not easy, and deciding what technology industries are, is also not quite so easy.

We need to spend some time understanding what we mean by competing and winning: What would be a successful outcome? What would it look like? It is clear that more is involved than science and technology superiority, manufacturing superiority, or even economic superiority. Success should involve some concept of quality of life for our citizenry and requires the balance of many attributes.

We will need to assess the legitimate interests of our competitors who are also our trading partners. Many are our allies in a broader sense of the word. It is unlikely that we will reap the benefits of a high quality of life, unless they also succeed. To guide our policies and our behavior, we need to have a concept for our success which includes success for our trading partners.

Let me run over, in this brief time, some of the salient features of the current situation that I see, although it is by no means comprehensive.

I'll begin by noting that we are the world's only superpower. This is a unique attribute of our society and of our time. It will color every relationship we have with other societies. It demands leadership behavior on our part in all aspects of international behavior. I will return to that theme.

To be the world's community leader, we will have to sustain a leadership position in major elements of national life, which includes moral authority, political stability, economic power, military power, industrial competence, science, technology, and the productivity of our residents. Notice, I use residents, rather than citizens.

We will be expected to lead and we will be resented when we do. Our economic success will be expected and resented and fought against unless we can translate some of our success into the success of our partners in a non-destructive way. In my view, there will not be a global environment for our well-being unless we lead the world community toward this objective and provide the political infrastructure needed to achieve it for us and for others. Only our society is in a position to do that.

We are the largest integrated market. We have a world class position in science and technology. We have a strong manufacturing sector, a superior systems position and a powerful service sector. Statistically, we are the most productive society in the world. These are not bad attributes and it is a very strong position from which to consider the future.

On the other hand, we need to consider that North America constitutes roughly 5 percent of the world's population and will be smaller in the future. We are a minority in essentially all of the social measures of culture, race, and religion. We now participate in approximately 20 percent of the world's economic activity and that will reduce to something closer to 10 percent in the next couple of decades.

North America, Japan, and Europe constitute only about 800 million people, but participate in more than three-quarters of the world's economic activity by any measure. There are more than 4 billion people in other societies who want to participate. The information revolution has permitted them to see what is possible as a result of the efficient access to science, technology, and industrial techniques. Many of them are making great progress. And as they do, they are performing many of the jobs which were historically performed here. As competitors, they are working hard to compete with us and the rest of the industrialized world.

Our morality demands that this large segment of mankind have the opportunity, even our help, in making economic progress, because we cannot succeed in the long run unless they do. I make jet engines. We put them on Boeing airplanes from time to time, and neither Boeing nor United Technologies will do well unless the citizens in China have the price to buy a ticket on an airline.

But we have some strong advantages which I believe are strategic and unique in making it possible for both us and our partners to gain. Our economy, industrial base, technology base, science base and military power are second to none. Those are the bases for global leadership for our society which should be exploited.

Our political system, even with all of democracy's turbulence, provides stability, individual freedom, and an entrepreneurial economic system. While we do not have the advantage of tribal coherence, which some other societies enjoy, we have the crucial attribute of individual freedom in a diverse population.

I have noticed that it is difficult to persuade the determined foreign skeptic of the value of individual freedom and diversity. But I am persuaded; and I believe a large number of the rest of the world are persuaded. I believe there are enabling virtues of our society which will not easily be emulated elsewhere and ones which we need to feature as a comparative advantage.

Conversely, a weakness is the economic, education and skills gap between the highest paid and lowest paid of our society. This gap, which is widening, puts at risk our political stability, our moral authority, our ability to provide a competitive work force and any national feeling of a superior society. In my judgment, we will not fulfill our promise if this aspect of our society is not corrected.

Finally, I would like to make a special case for our systems and integration advantages. As systems become more complex, with more information systems content and more international character, two premier attributes needed for economic advance will arise. The first is the capability to organize and integrate multicultural efforts. The second is the ability to integrate the system, technical, industrial, and financial aspects of all kinds of activities.

We have a unique and almost uncatchable capability for this segment of economic activity. We excel at information systems, which is the primary ingredient of a systems capability. We have an industrial base and a superior market position in all aspects of systems and integration.

The value of the diversity of our population cannot be overstated in my judgment. Our citizens are experienced at dealing across cultural lines as individuals every day. And it is a critical attribute for multicultural contribution.

Success in this systems and integration segment will be the unique ingredient needed for a high quality of life for our society. It is an appropriate role for the work force of the world leader. In fact, our leadership role makes this almost exclusively ours unless we fritter it away by not recognizing this as a dimension of advantage.

How do I feel about our approach for the future as a nation? First, we need to recognize the challenge, which is different from challenges during past decades and different from challenges faced by any other set of societies in the past. We should make it our objective to maintain a world leadership position. That is a distinguishing feature of our society at this time in history.

I reiterate that this means a broad connotation of leadership, including moral, economic, political, industrial, technological, scientific, and social. Excellence in such things as health, agriculture, and national security continue to be a necessary part of our national objectives. I believe we need to retain a strong manufacturing base. The ability to produce things of unique value is one of the attributes of a leader. It is a driver for converting science and technology to societal wealth. It provides for high value employment and is an important aspect to excellence in systems and integration.

But we also need to recognize the importance of a strong and productive so-called service sector including: entertainment, leisure, and information management. These are also areas where technology, systems, integration, and innovation are important. We already have a strong position in the service sector and we have a comparative advantage for continuing to excel.

We should emphasize systems/integration as a North American attribute and stress the integrating skills of technologies and information systems with their supporting activities. We must maintain a favorable environment for capital formation, training, education, and quality of life that will be necessary to attract and retain high value added employees for these activities.

We need to sustain a superior infrastructure for these areas of activities: infrastructure elements such as communications, transportation, information systems, and access to health. The training and education of our citizens are essential to our progress. Our superior infrastructure in these areas is tangible evidence of our status as an advanced civil society. These infrastructure objectives and national missions of health, agriculture, security, and leadership should be important drivers for government support to translate science and technology into industrial practice.

Let me conclude by saying that we in this room have had the great fortune to live in the last half of the American century. It should be the prologue for a great future for our society. However, we've benefitted from the exit situation of World War II and in my view, we benefitted from the subsequent cold war, however risky it might have been.

I believe the paradigms for our success in times ahead are different. The competition is showing up in different forms. While success will depend on science and technology leadership as an essential, that will not be sufficient. They will need to be coupled to others of our comparative advantages.

I see no reason why we cannot thrive ourselves and participate in the advance of other societies while we do it. Thank you.

DR. PRABHAKAR: Super. Thank you, Bob. I'm going to start off by asking a question.

You touched on quality of life and I guess I'd really like to double-click on that and ask: What do you mean when you use that term? How does it relate to the concept that you advocated at the beginning of your remark about how important the success of our trading partners is in order that they have money to buy the things that we wish to create?

Would you like to comment on those relationships a little bit?

DR. HERMANN: I had thought about trying to pontificate a bit about the quality of life issue, but I didn't think there was time to do it. I do not pretend to be an expert on the quality of life and certainly would not like to speak for all of you on what the quality of life is. I always try to remind folks that I was an Iowa farm boy. So we understood what the quality of life was back in those days.

In response to your question, I have identified some exemplars of what I mean by quality of life. I would say first that individual freedom in an entrepreneurial environment is a quality of life. And I note that it's a quality of life, because I appreciate it. And I also note that large numbers of people around the globe look at us and wish to come here and participate for that idea almost by itself. We would not like to do anything in the name of economics that caused us to dent that.

The next thing is that our citizens be secure from physical harm. So security is a big deal. I believe it's an enabler of economic success. You really can't have economic success if you don't have security or even if it's in doubt. I am speaking here of security for the nation, for your community, for your family and for yourself. So this is not just a national security issue in the external sense. It's also an internal security issue. It has to do with being safe where one works, lives, and plays.

I think the third entry I have is the opportunity to add value to society and to obtain material and psychological awards through work freely chosen. It's okay to have jobs, but to some extent prisoners have jobs. The kinds of jobs that one has and what that offers is very important.

An important issue is access to quality health care. The availability of means to make one's life both extend and be reasonably high quality while one is alive is probably going to be a long sought after commodity.

Access to ideas, cultures and other places on the planet is important to quality of life. That is, I would like to retain access, not lose it, in the actions taken to preserve our national economic well-being. I would not like to get into a position where we did not have free access to other ideas, other cultures and other spots of the globe.

DR. PRABHAKAR: I think there is plenty there to chew on, so let me throw it open and ask who would like to dive into this conversation.

MR. HOWARD ROSEN: I think we tend to emphasize the competitive part too much. I'm not as concerned about competing. What I'm really concerned about is living standards and people's ability to live comfortably. And I'm concerned about that not just in absolute terms, but in relative terms. Not relative to Japan, but relative to the way we were.

I don't believe in the comparisons about the way we're living versus the way the Japanese are living. That doesn't mean anything to me, because I'm not Japanese. And I'm not going to be in Japan. So I don't really care how much money they make. And if they make more than I, I don't know if that's really going to be an incentive for me to make more money or to want more.

The question is, why is it that the economy for 20 years was growing and incomes were growing, and then in the last 20 years the economy has been growing and incomes haven't been growing? Now, that may have to do with competition, but I'm not sure.

I think we constantly have to keep our eye on the ball. And the ball is living standards and wages. The wage problem may be a distribution of income problem, which I believe has a lot to do with technology. It has to do with the kinds of investments we make. I don't think it's the traditional distribution of income of the rich getting richer at the expense of the poor. I think it has to do with a lot of choices that we've made and now we're paying a price for it. It has to do with how we create income and how people win that income through work.

I'm just coming back from a conference in Japan where I had the benefit of being the only non-Asian. I was on a panel with four businessmen from the Konsai region who were asked: What was the strategy for their companies under Asian Pacific Economic Corporation?

Each one of them independently—they had prepared their remarks before—had calculated how much their companies would benefit if the billion people of China would buy their products. It was kind of hilarious. Someone said, you know, I produce beer. And if we could sell an additional billion bottles of beer a year, I would triple my revenues. They said this.

I sat next to the moderator and in answer to the question, What's the strategy? I wrote in big words, China. And that makes me think that there's a change in the way we've looked at opportunity. Now, we're looking at the opportunity that there are a lot of people over there regardless of the fact that they don't have money, but potentially may be able to buy our goods. Forty years ago we were not thinking about the size of the market, but we were thinking about the quality of that market, i.e., I'm talking about Europe. By going into that quality market, the quality of our producers went up.

I know this can sound like bidding down wages. There is an element of what I'm saying in that, but that's not my point. My point is that we're advocating going to where the markets are big. We're

going for the scale economies. Because if we could only sell a billion of X, just think how rich we're going to be. I think it's a very short-sighted position.

Now, this is all heresy. We should be working towards opening markets in China. But China is not going to solve our problems. It's not an issue of lack of markets. We criticize the business community sometimes for having a short-term perspective, and yet this is a very short-term perspective, in terms of how do we raise incomes in the long run. It's not the policies that we were following 50 years ago. And I don't know why. I think it's changing now out of desperation.

I shall end by saying that there isn't any question empirically or in anyone's mind ideologically that technology contributes to raising living standards. The question is, What's the appropriate way of doing it? And that's where we've been having the debate. There is a need for more empirical work to prove what I believe to be the case, that some kinds of investments stimulate other kinds of investments and things like that.

DR. PRABHAKAR: That was a lot to chew on, too. You drew an example in which you implied that there was a link between large scale markets, such as in China, and lower quality of jobs in contrast to high value added markets, potentially high value added jobs, and therefore higher living standard.

MR. ROSEN: I think that there is a clear risk of that happening. But I can also argue that it can be done in a way that we don't bid down our wages. I believe both ways can happen. If we leave it unbridled, we could end up with your model, which is bidding down wages.

DR. PRABHAKAR: Bob presented another view of the future in his example of jet engines on Boeing airplanes and Chinese workers who are able to pay. I'm not sure that that's what the future looks like, but once trading partners get on an economic cycle of growth, I think those dynamics start changing. And, therefore, maybe it's not a bad first round strategy to focus on where the volume is. Please dive in.

MR. YOCHELSON: It is unusual and striking that the societies that are most dense in technology and are most innovative in technology, the United States, Europe and Japan, are all projected to be relatively low growth societies. It is not at all strange that industry is looking to the economies that are projected to grow at 6 percent to 8 percent in Asia and perhaps in our hemisphere, all of whom are less technologically dense or sophisticated than we are.

The question that is more striking to my mind is why is it that the most technologically advanced societies are growing at 2 percent to 2.5 percent? Furthermore, nobody has yet figured out how do we break out of that slow growth rate.

MR. ROSEN: First of all, yes, we can sell our existing products or existing industrial structure to China and we'll push up our growth rates. But that's a short term stimulation of our growth rates. That's not what I'm looking for. If I want long-term growth rates, I want to continue moving up that curve. Selling my regular technology or low technology goods to the Chinese, is not going to do much for my long-term growth.

I guess I disagree, John. There are some people who have suggested the cause of the slow growth in the industrialized countries. In the United States, I think a large part of the problem has to do with our investment decisions. We have not increased our net stock in plant and equipment as a percentage of GEP in 15 years.

MR. ROBERT J. SALDICH: As a company that's active in the Asian market and in China, I'm sort of puzzled by your assertion that what's being developed for sale there are low technology products. It's the opposite. When China builds a telephone system and we sell telecommunications equipment into that system or airplane engines or almost anything else that America is successfully selling, it's the best

we've got. We're not selling brooms to them. The low technology stuff they're going to make themselves. The high technology stuff is what we're selling into those marketplaces.

As our businesses succeed, by capitalizing on that growth opportunity, that adds to the growth of our country. So I'm just puzzled by the assertion that seems to underlie what you said.

MR. ROSEN: Yes, you are correct, although I don't know how many telephone systems you can sell the Chinese. If you set up the telephone system there, I don't know how many more you do after that.

MR. SALDICH: Let me just tell you how many. They're building 8 million lines a year, 8 million lines a year.

MR. ROSEN: I'm not suggesting you shouldn't be doing that. I'm not suggesting that at all. But if that's our total strategy and we're not investing in the next level of that telephone system that the Europeans may buy, then we are still short sighted.

MR. SALDICH: But we are. We are.

MR. ROSEN: Okay. That's the question. That's the point.

MR. LYNN WILLIAMS: I wanted to proceed in a little different direction and maybe it's an old-fashioned direction. I'm more and more persuaded that a major part of our problem is the income distribution side of it, both here and abroad. I know that coming from a trade unionist, that's kind of a self-serving proposition, since our business is trying to do something about that.

I've been trying to sell a house for some months since I retired and there is no market out there to buy a house. Why isn't there any market? I think in my particular case, a middle class area in Pittsburgh, what's happened in that particular community is that the middle income people have just been destroyed in all of these downsizings. And the middle income corporate people who used to move in and out of our community and buy these houses and support a fancy educational system and all the rest of it, those jobs just aren't there. The income isn't there.

And yet we're in a society that's increasing wealth at an enormous pace. That's the heart of this technology. I have to agree with Howard, I guess, that it's self-evident that technology is a good thing. Clearly it is. Clearly that's how we've achieved the living standards we have now.

But it seems to me it's desperately out of whack at the moment. The benefits of all of this technological improvement are going to a very narrow band in our society. And we don't have the mechanisms to put the purchasing power back in the hands of the American people. You don't inspire the kind of investment that Howard is worried about if people don't see an opportunity to sell something. People aren't going to invest in steel plants if they don't see an opportunity to sell that steel. They're not going to have an opportunity to sell that steel if there aren't people making things out of steel. You're not going to make things out of steel and sell them unless there are customers out there.

The trade union movement is a big piece of that, but not the only piece. The major piece of it in America is the enormous hostility to the labor movement. The resistance and pressure that's put on workers, who want to organize and improve their circumstances and insist that their employers share a little bit, doesn't really exist in any other advanced country in the world. It doesn't exist even in some less advanced countries. But I think that's an element in it.

Other elements are this terrible budget cutting, refusal to pay taxes, and refusal to support a decent kind of civilized society. That has a lot to do with quality of life. I don't know if access to culture, travel and the other things Bob suggested is important, if we're not prepared to do anything to pay some taxes, provide cultural facilities in our society, and share the wealth that this technology is producing.

So I think there are some very fundamental distribution problems similar to those before World War II, that we resolved after World War II, that are emerging again and we have to find a way to distribute the wealth that this technology is capable of producing.

DR. PRABHAKAR: Thank you, Mr. Williams. Other comments? I wanted to pry a little bit more on terms that have been used here. Mr. Rosen, you talked about living standards. And Mr. Williams and Dr. Hermann both have talked about quality of life. Are we talking about the same thing when we use those terms? Mr. Rosen used living standards to mean wages, I believe.

MR. ROSEN: Incomes and wages.

DR. PRABHAKAR: Are salaries all that matter? Are there more issues on the table?

MR. ROSEN: Although it's important to have a high quality of life, I've been reluctant to get into that discussion because I'm not sure who has the vocabulary to even discuss those things. Just as an aside, I think one of most interesting things that I do is to sit with a group of theologians to talk about ethics in economics. Those guys have a view on quality of life that's very different from the view of those around this table, I'm sure.

So I'm not sure who has the vocabulary to talk about that, although we should. It's an important debate.

What we have been looking at has been restricted to incomes, not so much wages, although we do talk about wages. Now we get into some of the details of what's going on here in this economy, not all of it having to do with technology. We tend to make a correlation between technology developments and the shift in the distribution of income. In fact, there are some other things that are also taking place.

We're finding at the end of this 20 year to 25 year experiment that we have absorbed 80 million people into the work force, many of them women. And we applaud that.

Socially that's a wonderful thing. Women now have the opportunity to work. Coming from Japan, let me just say there wasn't one woman in this whole conference I was at.

On the other hand, we're finding that the only reason why incomes have been stable in the United States is because of the woman, because of the second earner in the family. So it's no longer just a nice opportunity for women to work. Women have to work now in order for families to keep their incomes the same or even improve them just a little bit.

This financial necessity for women to work goes right back to the quality of life issue. So they are very interrelated, but we tend to look at the wage-income side.

DR. HERMANN: I just wanted to intervene and reiterate that incomes and salaries are available, but they have to be paid to folks who are of value. If we wish to have open markets, which I think is a good idea, then we must use the word compete, because we will be competing with other folks who can add value at some transaction rate.

So my thesis has been that we must enhance our ability to do what we can uniquely do best. We're positioned well to do it. In order to change the balance of the distribution of income, we must educate ourselves. We must become good at those things which will be valuable in the comparative advantage areas that we have. That is not very original, but I do not see any escape from that equation if one is in fact going to compete. And I say it with some strength so I can listen to better answers.

MR. YOCHELSON: May I move us in a slightly different direction? Your opening presentation focussed on U.S. leadership in the world. What about leadership in the United States and the implications of technology for the kinds of people who are our leaders?

Is it an accident that Bill Gates is perceived as one of the two or three most influential people in the United States and that Michael Eisner is another one and Rupert Murdock. All of them rank above President Clinton in terms of the perception of power and influence that they have within our society and in the world as a whole. Leadership in the 20th century would be perceived as coming perhaps from politics, from the military. Are we going in a direction in which people from the technology world in the United States will have more expected of them by way of our society and by way of our leadership?

And, to return to Mr. Williams' people, do people who are at the cutting edge of this world of technology really understand what's going on in the middle class neighborhood in Pittsburgh? Do they have the links to the less trained in our society to the technological have-nots to provide the kind of leadership that we may need?

DR. HERMANN: Since I don't know any of those folks, I don't know. But I certainly believe that leaders such as Bill Gates and Michael Eisner and other folks who have power, are going to find it useful to have a really good, coherent, competent nation from which to operate. And, therefore, they will have to participate more aggressively in the collective act of governance of our nation than has historically been true in the past.

But I would say that will take time and I don't think we have the collective basis for action put in place yet in our idea structure. So I would say that ideas are a precedence to getting this straight. But I'm actually fairly hopeful.

The dimensions of the problems of the world are transnational in character. And institutions like big businesses and small businesses that go across sovereign territory are important institutions in global governments.

DR. PRABHAKAR: Bill.

DR. WILMER R. BOTTOMS: I'd like to go back to the issue that Lynn raised concerning income distribution, and I guess Howard raised it, as well. It's clearly a problem. But I believe the comments so far were focussed on the income distribution problem on the high end of the scale. There are some abuses in my view. But I think our income distribution problem in the country is really more focussed on the fact that there are a lot of people on the low end who are really outside the net. It's not the people who are receiving union wages. It's not the people who are in manufacturing jobs. It's the people who aren't in those positions, the people who don't have the wherewithal because of training or other reasons.

And the only way that we can really benefit from technology is to make sure that technology drives productivity, which allows us to be competitive. We have a segment of society that doesn't have that opportunity to participate in this increased productivity. In order for them to do that, they have to have appropriate training. It goes back to the primary school level, not just graduate school level. They also have to have adequate capital investment.

If we have training and capital investment, the wages problem on average will respond remarkably, because we'll take the people at the lower segment, who are dominantly in no jobs or service related jobs, and give them the ability to participate in jobs which have much higher value added.

And then the average wage issue can be dealt with, not by dragging down the top but by bringing up the bottom.

MR. JOSEPH F. COATES: I think the conference has to either engage or as a minimum acknowledge an unpleasant situation. And that has to do with the fact that the corporation is the primary organizational instrument by which competitiveness is implemented. And if one looks at corporate behavior in the last 15 years, I think that one can fairly say the following.

That it's become single focussed. It focuses exclusively on the shareholder. It's moved away from any concern for the community, for the managers, for the workers, for a set of other factors that have traditionally engaged it.

Secondly, in contrast to Japanese or German or French multinationals, the American corporation has lost all sense of patriotism, duty to country. If you're a Japanese business, you're a "Japanese" business. If you're American, you're American "business." Now, I think that's socially destructive, because what we're seeing is as the corporation caters to the stock market, as it caters to the pension funds and to the mutual funds, the executive leadership is constantly driven to improving the bottom line. And the consequence of that is out-sourcing, downsizing and constant implementation of the tools of competitiveness to in fact heave the social burdens onto places where in a broader sense of the constituency it wouldn't fit.

Now, add to that the present work force is 139 million people. By 2005, it will be 153 million people. Our analyses suggest that by 2005, 70 percent to 75 percent of the work force will be able to satisfy all of the internal and external demands of the U.S. economy. In other words, flip it around, 25 percent to 30 percent structural unemployment.

So I think you have to engage the question or at least recognize and defer to another time the role and behavior of the corporation as the primary instrumentality in enjoying the kinds of things that Bob so beautifully told us about. I don't find anything objectionable in what Bob has talked about. But what I find is he has failed to talk about the primary instrument for getting where we would like to go. Corporate misbehavior has become a core fundamental social issue.

DR. PRABHAKAR: I actually would like to challenge part of that, Mr. Coates.

MR. COATES: Don't challenge the best part.

DR. PRABHAKAR: Tell me which one that was. What was that part? I think there are elements of truth. I think the trends that you've described in terms of corporate behavior are accurate. But I think it's probably an overstatement to say that no corporation thinks about the national interest, that no corporation thinks about workers and management and issues, other than those for shareholders.

But I think fundamentally you've put your finger on a key point, which is that there is a national interest. It has overlap with the interest of companies based in this country. But it's not 100 percent overlap by any means.

You described the downside of that. The upside perhaps could be characterized as a vibrant market economy driven by focussing on shareholders' interest.

How do you do that trade-off? What do we stand to lose in the corporation?

MR. COATES: I think that you're wrong in your last conclusion, because if you look at the income distribution, we in fact have upset the pattern from 1920 to 1970. There was a very, very stable distribution of GNP across the five quintiles. Now, what we have witnessed in the last 20 years is a shift toward the top quintile, then the top decile, then the top centile, each acquiring a totally historically disproportionate share of the productivity gains.

Now that in itself is not so bad, except for two consequences. If you make $30,000 a year and I give you a thousand bucks, you're going to spend it. If you make $300,000 a year and I give you a thousand bucks, you're going to sit on it. You're going to put it in investment.

So as the top decile, quintile and centile increase their share of the productivity gains, they are not feeding it back into the economy. It's not in fact stimulating the very thing that you would hope it would stimulate. It's not providing the money to buy refrigerators and stereos and automobiles and

furnishings and homes.

So fundamentally we have to look at the question of how to keep the market economy healthy. How do we put the productivity gains in the pockets and purses of individuals? And that's the core public policy issue. If we grow 2 percent per year, which is realistic, we will double national income in a generation. But do we want half of that to accumulate in the top decile? I certainly don't. I want to keep the economy vital by putting those gains in the purses and pockets of ordinary people. And corporate misbehavior is effectively thwarting that national objective.

Let me illustrate with one recent anecdote. Boeing, a company that Bob is not unfamiliar with, just earned $800 million. And what's it doing? It's in labor strife to chisel some health benefits from its highly paid workers. That kind of dissonance characterizes the American multinational. Every penny they chisel from the worker is another penny to give to the shareholder and in turn to the mutual funds.

If you want to look at the economics of it, the core social issue is that the stock market has gone berserk. It obscenely rewards CEOs for their misbehavior, because they're all from Kansas. They all think that the only way the world acknowledges that they love them is double dipping them in money. And what we have to do is change that social structure. We have to Francophile or Germanophile the corporate mentality in America.

It's an unpleasant subject, but I don't think you can deal with this issue until you at least acknowledge it.

DR. PRABHAKAR: All right. Let's dive into this unpleasant subject. I think over here first.

DR. VAN DOORN OOMS: I'd like to do just a little basic economics. Number one, the European societies that Mr. Coates so admires in the organization of their work place have already achieved 10 percent to 15 percent structural unemployment rates and are likely to continue those for the foreseeable future until they begin to move, as they're very quickly learning, toward a more flexible labor market.

Number two, without wanting to defend the current distribution of income, I go back to what Mr. Rosen spoke about earlier with respect to the failure to save and invest in the United States. I just want to underline strongly my agreement.

We now have a net national saving rate of about 2 percent of national income in this country. We're not investing any of it, any of our national income, except a very small amount. We're investing barely enough, and perhaps not enough, to keep productivity growing at the approximately one percent rate at which it's been growing for the last 20 years.

The process that Mr. Coates deplores, people not spending all of their income on refrigerators, but actually saving a little bit of it, which indeed does go back into the economy through the financial system in the saving and investment, is exactly what we need.

It is no mystery why many of these Asian economies are growing at two and three times the rate of the United States. Krugman has documented it very well. It is not because they're brilliant, that they're smarter. They are saving 30 percent to 40 percent of their income and they're putting it back into investment. And they have labor forces that are also growing a lot faster than ours.

We're making the problem too hard in a way. The fundamentals of growth are pretty well understood. But the puzzle is, to go back to Mr. Rosen's earlier remarks, why productivity growth slowed approximately 20 years ago from a rate of about 2.5 percent a year, which was sustaining income growths at that rate in the first quarter century after World War II, to less than 1 percent a year, which is where we are now. And it is no surprise that incomes are growing much more slowly.

We don't really understand why productivity growth collapsed. We can account for a little bit of it in

terms of lower investment. We can account for a little bit of it in terms of technological factors. But by and large, it remains a puzzle.

So what do we do? The only thing we have left to do is to go back and try and address some of the things that we think are likely to raise productivity growth. And when we go through all of that, you come basically back to two. One is productive capital, which means saving and investment. And the other, and perhaps much more important, is human capital, very broadly defined, which takes us back to the skill issue. And I just again wanted to subscribe extremely strongly to what Bob Hermann was saying earlier about the importance ultimately of getting the skills to the people that need them in order to raise their incomes. I mean, that's really the bottom line and that's where it's at.

I think the great danger we face, which I hope this conference will address, is that there is a real danger of an inequitable dynamics. There is a real danger that as technology becomes more and more important, that those that have will get more of it. That they will get the benefits of technology in the sense that they will disproportionately get the additional skills. And the people at the bottom who don't have the skills, rather than catching up, will find it harder and harder to get a fair share of the human capital that we create in the society through technical change. That is the real issue and it's certainly my concern about income distribution.

Thank you.

DR. MacARTHUR: I'm rather interested in what the World Bank is undertaking. I suppose economists are involved in this. They are trying to work up a new way of counting a nation's wealth. It would be based on what you referred to as the productive industrial activity and human productivity. It would include certain quality of life issues such as a good environmental quality, not destroying our natural resources, our bio-diversity base and so on.

So I think that one of the problems about productivity in this country in the last 15 years to 20 years is that we have had too many examples of barbarians at the gate. You can't just count transactions as national wealth. The junk bonds, leveraged buy-outs and difficulties with our banking system have been very detrimental.

The early giants of capital formation in this country made their money doing things like building roads across the United States, the Suez Canal, or China. We could do that. Real work. The notion that Smith-Barney says, we make money the old fashioned way, we earn it, is maybe a good idea.
DR. LAWRENCE CHIMERINE: I'd like to pick up for a moment on the savings and investment theme. All of us would agree that in the long term, if we had a higher saving rate in the United States and a higher investment rate, long term economic growth and productivity growth would accelerate and eventually this would show up in higher living standards. But I think it's important how you get there.

The objective should be to channel more of the growth of the economy into saving and investment, but not at the expense of consumption in the short term. So the notion that it's okay that we're saving and investing more, but that families are being squeezed and spending is being adversely affected, that is not a healthy environment for long term economic growth and long term investment. We need balance.

The challenge is, how do we do that. How do we get the economy growing? And as we grow, how do we grow both consumption and saving and investment, but skew the share increasingly towards saving and investment in the future?

I want to pick up the point that Joe is making about corporate behavior. And while I think he probably overstates it in many ways and perhaps significantly overstates it, there is some element of truth that's been mentioned by others in what he says. And it seems to me the key point is that the system is increasingly skewed toward the short term.

The pressure to meet earnings expectations and a whole range of tax factors is increasingly pushing us

toward the short term focus, unlike many of our foreign competitors. If we want to overcome this problem, then we need to find policy changes that would push us more toward the long term.

I'm old enough to remember when we used to measure success in this country by how much we up-sized. Twenty years ago you were rewarded if you hired more workers, if you increased their wages and benefits, if you increased your R&D spending. Now, if you do that, you take a big hit on Wall Street. And the way to pick your stock up is to do exactly the opposite.

It all reflects the short term focus that is now far more pervasive in this system than it ever was. From a policy perspective, I think that's the number one challenge we have. How do we shift the focus more toward the long term?

MR. ROSEN: Larry, I think you're saying something important and I don't quite understand it. You said, in the long run, saving and investment is good. In the short term, we shouldn't save at the expense of consumption. I don't know what else you do with income.

DR. CHIMERINE: Mr. Rosen, what I'm saying is you can't expect families earning $25,000 or $30,000 a year, whose real earnings have been falling, to increase their saving.

MR. ROSEN: How do you raise saving in the long term?

DR. CHIMERINE: You raise saving in the long term, hopefully by getting incomes to grow and then you allocate a larger share of the growth to saving?

MR. ROSEN: How do we get the incomes to grow?

DR. CHIMERINE: Right now, I think the number one thing we ought to be doing is lowering interest rates and have a more accommodating monetary policy, which I think would give us the biggest bang for the buck over the next two or three years.

DR. PRABHAKAR: Let me dive in and ask to table that for a moment. Let Dr. Good finish up this session.

DR. MARY L. GOOD: I just want to add one thing to this. We're focusing a lot on the big companies and the big issues. Everybody around the table is doing that. I'd like to bring us back to the fact that the biggest portion of our economy in the United States is in the small and medium sized businesses. And that's true of manufacturing firms as well as it is of service businesses.

The Commerce Department has two kinds of high technology industry issues that it follows. One of them is the high technology products. The other is high technology industries. My view is we spent too much of our time over the last 10 years focussing on high technology products and not enough on high tech industries.

I would argue that today, the value of the technology which we've developed over the last 15 years is in the small and medium sized companies. Not only that, what we really need to do is to take back part of the American market.

The whole issue of deciding that we cannot compete in the United States on products in the American market at the lower end of the technology scale, is insane. Today, the processes are technology driven, but the products themselves are not.

Let me give you a couple of examples. Rubbermaid makes a very common commodity product. It is one of the outstanding high technology businesses in the United States. They can sell a rubber bucket in the United States against a Chinese import for lots of reasons, which I don't have to go into.

This economy is not going to get grown in the big corporations. They need to succeed and they need to go forward. And they need to do whatever they have to do. But you're going to have to grow it with new companies starting up. The average productivity will go up by starting small manufacturers across this country. And now we need some investment money to do that.

I would like to see people who have all of their money in these groups and so forth have a little more faith in being able to risk some of that. There's capital. It's not that it's not available. Starting up small, high technology processes gives you mundane products, but they can compete in the American market. So I hope we don't get bogged down talking only about what is happening in the Fortune 500.

**The Implications of Technology Growth for Industry**

DR. EVERHART: Thank you very much. Let me reassure you in view of what's been said about Kansas, that I went to high school there. So I do come from a humble background. And you will have to determine in the next 15 minutes or 20 minutes whether I've overcome it or not.

I just totally changed what I was going to say in view of the discussion over the last hour, so it may appear a little more disjointed than it would have. I won't totally change it. I have some comments to make about technology -- the implications of technology growth for industry in a global economy. But I was going to give you a historical example and spend a lot of time on that. And I will cut that historical example down on the grounds that probably some of you know it already, some of you don't know it and don't care about it, and why should I get into that.

I haven't spent a lot of time in industry, so it was a surprise to me that I was asked to speak about this subject. And I thought I'd approach it by making a couple of comments. Perhaps the one comment that I think might be most interesting to you right now is the idea that we're not in a technology economy. We've moved in this country in the last 100 years from what I would call a resource based economy, based on our natural resources. These natural resources may be minerals we take out of the ground or oil. We hit our maximum oil production rate in this country, I think, in about 1967. And since then, it's been going downhill and we've been importing more and more.

We have certainly been self-sufficient in agriculture for a very long time. We've been exporting agricultural products and we still are exporting agricultural products. But we've taught the rest of the world how to become more self-sufficient in agriculture. Fifty years ago I remember reading in the paper about the great famines in Asia. We don't read about those any more. China and India have become more self-sufficient in food, and that's because the technology that we applied in the genetics of seed hybrids and so on has helped them.

We based our wealth on productivity from factories. And we still get some wealth from productivity from factories. But I think we are moving—perhaps have moved—from a resource based economy to an intelligence based economy. And we haven't really figured out what that means yet. And it seems to me that's in some sense what this conference is about. And it seems to me some people, perhaps some of the countries in Southeast Asia—Singapore, for example—may have figured it out considerably better than we have and they may be doing the right things.

So if you wish to talk about competitiveness, it seems to me if we focus only on the bottom line of a corporation and is it competitive, that is very short-sighted. We have to focus on the entire fabric of the Nation, its policy and so on. It's appropriate that NIST and the Council on Competitiveness should sponsor this conference.

I think it's appropriate to ask if you're in an intelligence based economy: what is going to grow and what are the things based on intelligence? Whose names have been mentioned? Bill Gates. Now, how much natural resource goes into the products of Microsoft? You know, a few hundred thousand trees, because they print a lot of stuff on paper. A little bit of plastic for the disks they send out. But most of it is value added from human minds. And they're ahead, because they are ahead and they want to stay

ahead. If they don't stay ahead, they won't be a profitable company. And that's also true in jet engines. Think of the changes from the piston engine to the jet engine. That was a basic change.

I think there are several types of change one can focus on. Revolutionary change, I would say, was the change when we went from a piston engine to a jet engine-and most of us got here in jet powered airplanes if we came by air. The switch from radio to television was a pretty revolutionary change. You could see people. You could see what was happening in a foreign land. You could see what was going on in Vietnam, whether you were on leave in Germany as I was for a year, or you were in an American living room. That made a difference in the way that society reacted.

Now, there are some things that weren't revolutionary. Take automobile design. That's an evolutionary change. The cars I get into today—and I'm on the board of General Motors—still have a reciprocating engine in them, just as they did when I learned to drive in the 1940's and 1950's. There hasn't been a fantastic change in those cars. They look different and so on and the styling has changed, but that's what I call evolutionary change.

There are some labor saving changes. There have been two that impressed me a lot. Having helped my mother wash clothes with an old wringer washer with several tubs—the automatic washer was a terrific labor saving device. There may be a couple of other people in this room old enough to remember wringer washer technology. The most recent one, which I think is a terrific labor saving device, is the automatic breadmaker, which the Japanese had long before we did. I think it is one of the wonderful exports they've made to our country. If you've ever had to make bread by hand, compared with making it in a bread maker, you know what a labor saving device it is.

We have some timesaving changes that are going on. They really pick up the speed of things. For example, E-mail and fax have speeded up the interaction back and forth across the country. When Chuck Vest and I want to talk to each other, we do it by E-mail, because it's sure a lot faster. He's always someplace else when I call. I'm always someplace else when he calls. But by E-mail we can get back to each other in a few hours. And that's one way two college presidents can stay in touch across the country.

And think of the societal change that these things have brought, not just to travel to this meeting, but via t.v., the poor see how the rich live. The Asians see how Americans live. Aspirations are raised, motivation—things that this group hasn't talked a lot about—are extremely important.

My biggest problem in the university is to get people to change their attitudes, to get the students to focus on what the society thinks is most important, not particularly what the research professor thinks is most important. And we all have these problems in our businesses with attitudinal change.

One of the things that's happening is this technology growth causes us to reengineer, to use a popular word, the processes we use in our institutions—whether it be a corporation or a university. Now, a lot of that re-engineering has been accompanied with downsizing and so in some people's minds, it's coupled with, well, that's just the way you get rid of people. I think that's unfortunate. We need to change the processes. And we can do it—and in some companies, even add people if the company is growing.

But the difference between a Hewlett-Packard, for example, that's growing over 20 percent per year, even though it's a $25 plus billion company, $30 billion plus company today, is that it's in a field where there is an increasing demand for product. So, Dr. Good, when you say small companies will be the ones where growth will occur, I think that's true. But they have to have products or services that the customer needs. And figuring that out in a global economy, it seems to me, is a $64,000, $64,000,000, maybe even a bigger question-a billions of dollars question.

So it seems to me these are some of the issues that we have to focus on. And when we do this re-engineering, what we're really doing is empowering workers. For a long time—and I think the Federal

Government is to blame for a good bit of this—we have essentially been rule based. You know, what can I do? Well, look it up in the rule book. The rule book is so big, no one can look it up in the rule book any more.

And what we used to do is say, use your best judgment and we are going back, it seems to me, to a country which could get back to, use your best judgment. Tell the worker, use your best judgment and we're not going to fire you if you make a mistake. Use your best judgment and you won't have to look it up in the rule book. You can get it done very much more rapidly.

We're trying to do that in our institution. And I think many of you are probably trying to do that. In order to do that, we have to reinvest in people. We have not spent much money in training past the final degree that people get in this country. The better companies have. That's incidentally hard for small companies. And that's where universities, community colleges and others can play a role. I don't think we've done a terrific job in investing in what I call the mid-level, technical, high school plus technical training, either. And that's an issue, as well.

We have to look at this whole system and say: where are we weak and where can we improve? Let's do it, so we as a system, as a nation of people, will be very strong.

Perhaps that gives you a sense of what I think we should be talking about. Let me spend a little time on a historical example. It just covers my lifetime and it covers a lot of my experience in college and graduate school and research. It's a historical example of revolutionary change—going from vacuum tubes to transistors, which happened in about 1945 to 1960; then transistors to integrated circuits; and then, integrated circuits up through the whole scale of integration to the ones that we have today. These have been revolutionary changes, essentially decade by decade. And the thing that is so interesting about this change is that after about the first decade it was predictable. It was predictable because Gordon Moore coined the law which said that the number of active devices on an integrated circuit chip was doubling every year. It's dropped off a little bit, but it's still going up that fast -- or almost that fast. The tremendous increase of power and information processing was made predictable.

Once he had that law, Gordon spent most of his time at conferences trying to say to people, how are you going to use all of this? We know it's coming. How are you going to use it? Gordon Moore was trying to create a market. He spent his time trying to create a market for a product he knew he was going to have at Intel.

I think we have to have more of that sort of vision, looking ahead and saying, what's the world going to be like and how do we get ourselves ready to be in it?

I won't go through a huge amount of discussion I had on this transition in electronics. It made a big difference in industry, because in the beginning, no one knew even how to go from tubes to transistors. You had to learn whole new skills and none of the workers out there had it then. But the high technology corporations and here the small corporation did it. If you look at who were the leaders in tubes, they were GE, RCA—go look in an old surplus radio if you have one sticking around in the attic. Ask who are the leaders in integrated circuits today—not GE, not RCA. They couldn't change fast enough. Not Westinghouse. Even the leaders in transistors had a hard time moving in the integrated circuit field. Intel was not a company when the transistor was invented or when the integrated circuit was invented.

So that's revolutionary change. And these companies have adapted. Have they always adapted correctly? No. There was a time when Intel was not using its own information processing devices at all. I talked with Bob Noyce and Gordon who said: "You know, it's funny. We don't use computers very much in our business." They didn't use them partly because the software wasn't there and they moved too fast and they had a very good system of talking with each other.

But as you go through this revolutionary change, each company has to do what is necessary to make the

process go rapidly. I've lots of examples.

One of the things I thought I might do is just say what is the role of the university in this, because universities have to supply people. If you're going to be in an intelligence based economy, you better have some people coming out of universities that have some of the intelligence you want. And the most important thing it seems we can do in the university is to teach people to think, teach them how to solve new problems and give them a background that's broad enough, so when the new problem comes along that doesn't fit their background, they at least know how to learn the new material.

How many of you are working in fields that college really prepared you for? If you're a scientist or an engineer, I can virtually say almost no one. If you're an economist, I guess you've learned an awful lot since college, as well. And so on and so on and so on.

One of the things that universities are having to do -- and the whole nation has to do -- is fix our K-12 educational system, because it's not doing very well. If you compare the results of our K-12 system with the results of the other industrialized nations of the world and some of the non-industrialized nations, we don't compare very well at all. That is the human potential on which in the year 2010, 2015, the future of this country depends. And we're not keeping our eye on the ball.

Universities are just as culpable in this as anyone else. We have very large grants at Cal Tech now. This is not part of our mission, but we have faculty that say we have to become involved. We have a very large grant in which all of the Pasadena schools are involved. We're teaching kids and their teachers K through 6 about science, not details of science, but how you do science, why it's fun to do science.

This statistic bothered me the most when I heard it: a few years ago I learned that in a state university, in a different state, thank goodness, there were something like 30 students declaring they were going to major in chemistry and over 2000 declaring they were going to be undergraduate majors in business. Now, that isn't probably going to satisfy the nation in the best way if in the long term we have no chemists and all businessmen—because the businessmen won't have anything to sell. We have to make sure that we have a balance and that the rewards are correct.

I gave an example about Bill Gates to start with. Let me wind this up and open it for discussion by giving an example from Michael Eisner. I heard him speak about three weeks ago and he gave some clips from Toy Story. So I got a preview of it and I must say I found it highly amusing.

What he pointed out in Toy Story—and if you go and see it, I want you to remember this --was that the technology is pretty amusing and it's really good. Despite the technology, he said, the most important thing is getting the story right. He said, we went through six endings for Toy Story before we thought we had it right. Now, you'll have to go and pay your money and see if you think he got it right. When you see that movie, remember, to Michael Eisner, it was not the technology, it was the story. Both the technology and the story require an intellectual input. That is a natural resource that we have to use.

Thank you.

MR. YOCHELSON: Well, our horizons have been much widened and extended. Who would like to kick off?

DR. HERMANN: I would like to ask the economists how we should count investment in human capital. In other words, when you have a conversation about savings and capital and investment, how do you count the capability to produce value intellectually in that equation? I just don't understand. Perhaps an economist could give us a little tutorial on how it counts in the investment rate or not.

DR. OOMS: I really ought to defer to Gary Burtless who has joined us, who is something more of an expert than I am in this field. In our normal accounting, we don't include it. I mean, our normal

national income accounting, we include only physical capital.

But there is a tradition in economics now that goes back 30 or 40 years and, in fact, further. But in a formal sense, 30 years or 40 years. There is a tradition that recognizes the fact that in many respects you can treat the accumulation of education, of skill, of all of these abstractions that we talk about in models, in the same way that one can treat the accumulation of physical capital. Simply, that people acquire abilities to do things—and these have long-term payoffs over a period of time—so that you have an income stream in the future generated by an accumulation of these skills over some shorter time horizon.

Measuring it is extremely difficult and this is one of the problems. I mean, the measures that we use are extremely crude. They're accretions of years of schooling with some types of quality adjustments or amount of years in the work force with certain types of adjustments made on the basis of income as a rough proxy for quality or productivity adjustments of some kind. But that's conceptually what one tries to do.

DR. HERMANN: As a non-economist, shouldn't it bother me that we have this dialogue around only counting physical capital in an economy which is fundamentally dependent on intellectual capital for our future? I understand that it's easier to measure. It is not obvious that that's an excuse for being the only thing we measure. I'm not in the business, but it does seem to me that we shouldn't stand for it. Being precise may not be such a requirement because we arbitrarily decide the depreciation rates and a bunch of other things that are absolutely random, but on the other hand are folded into the process.

I'm looking for some way to imagine that we would have a wiser dialogue, a better understanding of what investment means and what its payoff would look like if we had a better way to deal with the fact that the creation of human capital has a downstream, future revenue stream which is similar to an investment in tangible capital.

MR. ROSEN: If I could, I just want to dissect your question a little bit. Are we asking, how do we measure how much we invest in education? Or, what's the return on our investment in human capital?

And what's odd is that you're correct. It's very easy to measure how much we invest in capital, physical capital. And we use those measurements of investment in capital to implicitly tell us something about the return on that investment. But we know very little, if anything, about that return on investment. When it comes to education training, we say, oh, we can't measure that. Well, I'll say that the errors in measurement are probably the same. It's just that we're willing to make those errors on the physical capital side. We're not willing to make it on the human capital side.

We do know how much we invest, how much we spend on education and training. We know. And we also know that it's going down in this country in relative terms. Now, what we don't know is what we're getting for that dollar. And we need to do more work on that. You're correct, we do need to do more work in that area especially as we move into this technology and intelligence based society. And just because we haven't done it doesn't mean it can't be done. But we do already know the first part of that equation.

There is only one way I know to spend on education. Somebody has got to put up the money. I'm talking about education broadly. So it's either going to be individuals who are going to pay for it—they have to have incomes—or, it's going to be a communal thing. But we have to pay taxes. Or it's going to be companies that are going to take some responsibility. And I don't see any of that happening. Maybe we all need to do it together, but someone has got to bring it together so that we all start doing it. But when we go to the firms, they say: if we invest in these people, these people just pick up and go to another firm. Or, we don't get anything back for it. You know, that kind of thing. I'm making a generalization and there are a lot of stars around this table. So, please don't take this personally.

One of the great ironies is when you fill out your taxes—your 1040 every year—you cannot deduct

training for a new job. Here we're talking about encouraging this flexible labor market and you can only deduct—if people even do this—training to keep your current job. It's the opposite of what we should be doing.

We should change that rule immediately and we should be encouraging everyone to continue education and to deduct its cost. Of course, you've got the problem with how to handle a basic college education, but we can handle that. We've done it on the physical capital side.

And to pick up on Mr. William's point, we all said we need to have education but no one is willing to pay taxes to have it. It's more than just saying it's a good thing.

DR. EVERHART: Let me make a couple of comments. It may be a little self-serving, but I think the country is in pretty good shape when it comes to college and graduate education. It's the K-12 part that is not working well. I'm not trying to point my finger, because I'm a citizen. We have a public school system and everyone around this table is culpable if the K-12 system is not working well. It's our responsibility. We can't lay the blame someplace else. So it's not a matter of pointing fingers. We're pointing the fingers and the finger is pointing at us.

When people come from foreign countries and try to break down our doors to get into our colleges and our graduate schools, we know a market is working and it's working in our favor. And, if you think a little bit about revolutionary change, one of the revolutions in change has been the number of people who go to college and the number of people who go to graduate school as a percentage of our population. I was the first member of my family to go to college. I got interested in it and I went right through to a Ph.D. That's a little unusual. But nonetheless there are many of the students in my institution today that are the first members of their family who have ever gone to college. We are utilizing human potential because of an education that other nations aren't utilizing. So we're doing some things right.

How to use our human potential is always a subjective judgment. When you hire people in your firm, you may use data, but in general, it's a subjective judgment. When we admit students to Cal Tech—and most of the other universities do the same thing—it's a subjective judgment. We have more applicants, thank goodness, than we can admit and we try to choose the best ones. So it seems to me that we have to really figure out how to use our human potential.

One of the problems of having computers is you can do spreadsheets. And anything you can quantify, you can put into a spreadsheet. Generally it will come with as many significant figures as you want. Most of the assumptions aren't worth one figure or certainly no more than two. So it's really very funny to see some of these projections of what your budget is going to be next year, to five significant figures, when you have no idea what it's going to be to more than two. But that's another issue.

I would say one other thing while I have the floor, and that is I don't think we can over-emphasize motivation. One of the reasons corporations pay their CEOs and high level employees a fair amount and then try to tie them up with stock options, and so on, is to keep them from moving—because in our system they're very mobile. The way our system works they have to suffer an economic loss if they move. If you do it right, they stick with the corporation for a very long time.

Hewlett-Packard is a company that gives every person in the company the same bonus. It's a percentage of their salary on the profit made. And, of course, there's a difference in dollars for different people. But everyone is motivated by that. And if the corporation grows, it's a bigger percentage.

MR. COATES: Is that Cal Tech arithmetic? Everyone gets the same bonus?

DR. EVERHART: Everyone gets the same percentage bonus.

MR. COATES: But that's not what you said the first time.

DR. EVERHART: I defined it quite carefully, sir, and I'm glad you were listening. Okay.

MR. YOCHELSON: On the list, I have Al Westwood, Diana MacArthur and Curt Plott.

MR. ALBERT R. C. WESTWOOD: On the subject of technology and competitiveness, I have a question for Dr. Everhart. It seems to me—I suppose to most of us—the concept of continuous education is crucial to continuing competitiveness. So we all are also aware of the fact that education as we practice it today is getting simply too expensive. A hundred thousand dollars for a bachelor's degree is getting to be par for a course at a major university.

I'm wondering whether the time has come for a paradigm shift in the way we even think about education. At first, it would have to be continuous, as I've mentioned. But that implies, I think, in reality that we can't any longer consider the notion that the student goes to the university. We have to consider that possibly that the university goes to the student. And, of course, that opportunity now exists with modern telecommunications.

I wonder if you would like to address the question, how do you see the university playing its role in continuous education in the future such that we can in fact maintain competitiveness?

DR. EVERHART: I think that's a very good question, Mr. Westwood. I think things are going to change. They have already changed. There is a technological university on t.v. now. And you can learn a lot from it. If you pay, I think you can even get a degree from it. The British have had this Sort of education going on for a long time and I think it's very important.

I think there is some value for students at age 17, plus or minus a year or so, to get together with other students from different backgrounds for a few years and with mentors, who are probably called professors, and come to grips with a society that's probably different than the society they grew up in. When I went from Wichita, KS, to Cambridge, MA, for college, that was probably the most defining point in my life. And it was, I think, a very fortunate decision. My parents, or at least my father, thought I was silly to go so far away to school, especially when I would have to pay and work to do it. We disagreed on other things, too. Maybe some of you can remember those days.

But coming back to your question, I think the present college experience is important. I agree with you that people have to get educated the rest of their lives. And how they're educated even in college is changing. We have faculty that are developing videotapes and interactive computer programs which enable students to learn more quickly. They understand concepts faster and better. And they will come out of college with more value added. But those same videotapes, those same interactive programs can be used in a non-college place. They can be used in your home.

And increasingly, I think, people will be using video instruction and computer instruction of that sort. The computers one has in a home, or can have in a home today, for about $2500 will do all of this and more. And I remind you 10 years from now, those computers will cost $500 or $600 and much more powerful computers will be available in the home. Using the Internet, a student will have a vast set of resources around the world available. We are in truly a time of paradigm shift in education. And I think many people in education recognize that.

But, again, people feel threatened because they're changing, they have to change. And change is always threatening. It doesn't matter whether you're a Ph.D. in biology or a high school teacher. But we have to change over a whole broad spectrum. That's the part I think that's threatening.

DR. MacARTHUR: About three years ago I attended a reception for Jack Gibbons. And present at the dinner were heads of various scientific bodies, associations of universities, research universities, National Science Foundation, so on and so forth. The discussion after dinner was led by the host who

shocked me by having the lead question be, do you think that universities should practice birth control in turning out PhDs in physics? I've heard that recently again. I think that I'd like to have you comment on that because what kind of an irony is this?

DR. EVERHART: My short answer to the question is no. I don't think we should practice birth control. Let me tell you, though, what I mean by that. I have met Ph.D.'s in physics from Cal Tech, who are leading computer companies. Two of our latest Ph.D.'s in physics went to Wall Street. The people there seem to feel that our Ph.D.'s know more about derivatives than they do. There is complexity in many areas of life where very careful analytic thinking can provide a great deal of value added. But if you ask me, do I think every Ph.D. in physics or any other subject should expect a job in a university doing what their mentor did, the answer to that is also no. I do not think they should expect that. They should understand that what they are doing is getting rather expensive training that will enable them to do a lot more than if they hadn't gotten it. But they're going to have to be fast on their feet in a changing world. And the broader they are as they go out and learn other fields, the more value they will have for the society they expect to serve.

MR. RUSTY PATTERSON: In a way, I think I'm surprised that we're surprised that there is a growing disparity between the different levels in our income.

If in fact intellectual capital is an underpinning of our future development, and so on, we continually under-invest in the same group of people in our society. If you look at how we finance schools and the ability to invest in that particular intellectual capital, you quickly find the remarkably large disparity in investment per pupil between what you spend in a large city school and what you can spend and what you can afford to spend in a suburban school.

It is consistently true that we fail to invest in the non-college bound, if you will, in our society. And then when they complete high school or don't complete high school at ages 16 to 25, in the transition from school to work our country does not invest like many European and other countries. We have this patchwork, fragmented sort of system that supports or doesn't really support 16- to 25-year-olds as they wander around from job to job, dead-end and low wage and often not leading to any real development skills before they find a home in our work force, or intellectual capital and maybe a better job.

When we look at what we do in building human capital mostly in business, it is done by larger corporations because often the smaller or medium sized corporations don't have the amount of money to invest. If you look at who receives training, it is largely those people who received the education before. So, your managers and your technicians and your professional support personnel continue to receive this investment by businesses.

But if you think about it a little bit, I don't know a CEO who gets his bonus based on his development of human capital or intellectual capital in the organization. The reward systems and the measures that we have right now seem to favor non-investment in this very critical factor.

I would agree very much with what Tom said about it being a knowledge-based economy that we're moving into. I think we can expect fewer and fewer employees producing more and more goods in a manufacturing sector. More and more the intellectual underpinning of our economy will be what we spend on people. And yet we still have, as Howard said earlier, all of these disincentives and very illogical tax rules about investment in people.

So it's not a surprise when we sit down and really think about it.

MR. FRED KITTLER: Just some perspective and then a question. As it looks from an institutional perspective, we're in this revolutionary time going into a knowledge economy, using information technology to automate the processes, complex processes in the economy. And some processes are susceptible to that automation -- the easy ones, like making jet engines, or what have you—helping us to compete with foreign corporations. Corporations are using automation technology to compete more

effectively.

They are using the resources in the economy effectively and in effect bidding up the price level for the inputs, for the labor force, for rents and other factors that everyone has to use. Meanwhile, other sectors that are much less susceptible—government, health care, education—have to pay those rents. They have to pay that price level. And they come off as being less productive, because they cannot automate as rapidly and can't keep up in that particular mode.

Consequently, as we begin to see some more use of technology in health care, some rationalization of structure, we still see pressure in government. The question is, how can we use the technology in education to bring up the lower strata of the work force and bring them into this knowledge based economy? Really, where do we use technology in education?

DR. EVERHART: That's a very good question. And I think there are lots of ways we can do that. For example, California is towards the bottom of per capita spending on students. And I am not proud of our K-12 educational system in California. Pactel has said that they will wire every school in California for the Internet. Now, this is going to be a tremendous paradigm shift for the teachers. They don't even have a telephone in their classrooms. Now they're going to have a computer terminal. Some of them will be scared to death about how to use it.

But the good news is that the software is getting good, as one wag said, you know, computers are getting so easy to use that even managers can use them. I spent last weekend installing a new computer system for my grandchildren. And I think my grandson at the end of one week probably knows that computer system far better than I did when I installed it. He's seven years old.

And it seems to me that if he and his brothers didn't have that computer, that they might not get the education in a rural school system in Vermont that they will need to compete with the students from the private schools and the students from Hong Kong and Singapore and other places in the world.

So there are lots that we can do. I thought you were going to ask me about banking. And it seems to me if the banking systems are really good and the processes that take place in the distributed bases were monitored correctly and came back to the headquarters, Bearings might still be in existence today, just as an example.

So we have a lot to do to re-engineer our processes, it seems to me, in government and in industry and in education.

MR. YOCHELSON: I have four on the list. Perhaps we can do all four and then give Dr. Everhart the last word to close off the session, starting with Mr. Van Erden.

MR. JAMES VAN ERDEN: Thank you. I just wanted to follow on something that Dr. Everhart said earlier. And you said the country was in good shape at the college level, but the K through 12 system is in deep trouble. And I want to build on that a little bit. Curt alluded to something that's been underway for some time and that's the school to work transition issue. And it's not just K through 12 reform, but it's what happens to the kids who don't graduate with a baccalaureate degree. Seventy-five percent of our folks, kids don't. Only 50 and now somewhere around 60 percent actually go on from high school to college.

So the issue of K through 12 reform is critical, but the issue of how the transition system works that sits on top that to help those kids move into the work force is also very vital. And I would just say there has been a lot of folks over the last 4 years or 5 years who have worked a lot on this issue. A lot of money has been put in by the Clinton Administration for this school-to-work transition—several hundred million dollars a year.

And while you have some good examples of some leading companies, like Motorola and like Siemens,

who have done some exemplary work that's been, I think, highly respected, I have two little anecdotes. The folks at one of the Siemens plants in Florida, the kids who took the national apprenticeship exams from Germany scored the highest in the world. And these are kids in a Florida school and they were not kids who were creamed into the program.

Yet, the problem comes back to how you value training in education. When you go back to employers and you say, isn't this critical? Everybody says, yes, we have to increase the knowledge of our workers. We have to be competitive. Very few employers will enter into that discussion. They'll enter into it at the college level. They won't enter into it at the high school and the transition level. We're spending a lot of time right now thinking about how you bring employers to that table.

It's very, very difficult. Even with money to help them through facilitation and setting up programs. Maybe it's a discussion for Gary in the next session. But I'd like to come back to say, what is it that you really need to do? Whether it's in terms of accounting, whether it's in terms of return on investment, or whatever it is, how can we get employers to the table?

Educators are there. The huge structural systems of education in this country are there and they're ready to work on school to work. The problem is it becomes just another education program, another co-op or another voc-ed. It doesn't become the real transition program into the work place.

One final point and I'll stop. It's back to how you evaluate or value that technology in the education of your workers. I had an example of that at a large aircraft manufacturer a few years ago. We were talking about the issues that Howard raised about the tax code and how you value increased education in your workers. Look at the old pictures during World War II of the production of a wing spar on an airplane—I remember the pictures, where there would be 30 riveters all standing there with their riveting guns, you know, making the wing spar. If you go to the new technology plants, you'll find in one particular plant -- and because the press is here, I don't want to mention the company—there were two people working on a huge C&C machine, building a huge wing spar. And the accountants and the people who were taking us through the plant said that there are two people now, but next week we're automating the bottom job so there will only be one.

We went back to the accountants in the company and the comptrollers and we said, how do you value the human capital of the people who produce that wing? They said, we don't value it any differently than we did in 1940. And I said, but you have one person versus 40. Isn't that one person doing more? Well, you might be right, but we haven't changed. And I think that's a lot of the issue around how do you value training and how do you value education.

MR. JAMES AUERBACH: Mr. Van Erden just picked up exactly on the first point that I wanted to comment on. It's on the state of postsecondary education in this country. I would just note that we are holding this conference in Montgomery County, Maryland which is in fact one of the wealthier districts, jurisdictions in the country. And it has a reputation for one of the finer school systems in the country. And they will probably note—and I have served on advisory groups in Montgomery County to both the K-12 system and the community college—that 85 percent or more of their students go on to postsecondary institutions. What isn't said is by the second year, those averages have dropped right down to the national average. That's, I think, something that Mr. Van Erden was saying before. While you probably note how many people have started in postsecondary institutions, it's quite clear that the people who finish are far fewer.

I think a more significant question then I would have of you is: What are we really doing? How well are we really making use of those degrees that are granted in the work place?

We have as the result of the impact of technology many people working in jobs for which a college degree really is not necessary, despite all of the talk about the needs for reskilling and higher and higher education. In fact, many of these jobs do not require college degrees at all. And yet we have an increasing number of people going out into the work force with college degrees who will become

increasingly frustrated as they're unable to use many of those skills that they learned.

Let me also just ask you something else, as well, which is on a different aspect of what you were saying. I was struck by your admiration of the impact of some of the technological innovations on our personal daily lives, from automated breadmaking machines to the latest washing machine. It sort of brought me back to the 1950's when we were filled with stories and commercials and things on television about the great benefits that all of this technological innovation would give to the homemaker in her home at that time, and how the new oven and the new washing machine would make things so much easier and so on. The implication was that we would have more leisure time and that our lives would be less driven by work from morning to night.

In fact, it seems that the cumulative effect of some of these innovations is just the opposite. We seem to be driven by a work week which is longer and longer, and for which we have less and less leisure time.

I just wondered if you might comment on that.

DR. GRAHAM R. MITCHELL: I just wonder whether the discontinuity might be greater than we're preparing for. We're guilty of linearly thinking our way into something that's very different. It struck me in the early discussion about growth and wages, that they really may be sort of separable. That while we might be able to set up the conditions for growth, it seems to me there is a compelling argument that says that wages and lack of increase in wages has got a lot to do with the number of people around the world who are willing to do those jobs for less money. And it strikes me that we might be being a little simplistic by simply assuming that as we educate more people, they're guaranteed to have a high standard of living. That, to some extent, is going to be dependent on what the rest of the world does. And if they, too, educate a lot of people in some of these similar skills, will that not, too, bring down pressure on salaries in the too able professions?

DR. RUDOLPH OSWALD: I wanted to take part of this theme and carry it a little bit further. Maybe both Mr. Auerbach and Dr. Mitchell said it in a different way in terms of how you value workers, but I'd really rather pick up Tom's theme earlier of empowering workers. And Tom spoke of it in terms of changing from rule base to use your best judgment.

What I found interesting is where he stopped. It seems to me that so much of the empowering workers is not about empowering workers to have a voice in the distribution of the gains that are made from this element. Lynn talked about it in terms of the attempt to prevent workers from forming unions, so that they would have a voice in that distribution question. And I think Bob touched on it in a different way earlier. He talked about security in terms of national security or security within our own neighborhoods.

I would talk about Dr. Everhart's empowering workers to say they have no voice in security on the job. And it is that insecurity on the job that I think is a matter that undermines the quality of life that was talked about.

And the other element that I thought Tom did not talk about in terms of empowering workers—and it goes a little bit to the theme that Dr. Hermann talked about earlier—and that is, workers are not empowered to participate in the underlying judgments about whether their jobs are performed by the corporation or are being subcontracted out or are being foreign sourced, the elements that really underlie the question about economic security.

I think it is this other side of empowering workers that is as important as whether they are able to use their best judgment on the job or whether they are following rules.

MR. CHARLES LARSON: I couldn't let this discussion of the importance of knowledge workers pass without emphasizing the critical aspect of good management. You can have the best and most knowledgeable workers in the world, and unless they're managed effectively, we're not going to

compete effectively. So we have to invest in good management practice, as well.

Going back to Bob Hermann's question in regard to economists accounting for the impact of knowledge, I don't think economists account for the impact of good management practice in productivity analyses, as well.

MR. YOCHELSON: Dr. Everhart, the last word for this morning's segment.

DR. EVERHART: I'm not sure I can do justice to all of the comments that have been raised. I think the one thing the discussion shows is that it is a fairly complex subject. But let me try to say a couple of words.

First of all, what happens to high school graduates and those that start college and don't graduate from college. I think that's an important problem. And I would say a couple of years of college probably helps a person along life's way, because it's really the knowledge you get out of college that's important, not the degree. It's really not even the grades 10 years down the stream. It's the knowledge you take away. And someone that learned a lot but doesn't take tests well may in fact do very well later in life. It's an important problem that I haven't thought a lot about, because it's not my problem. But it's certainly society's problem. And as a group around this table, we need to address it.

About the number of college entrants who don't graduate—it's certainly true that happens. At most of the good colleges, about 80 percent to 90 percent of the students that do enter do graduate. So the drop-out rate is not so big there. I'm not speaking for academia as a whole, but only a part I've been associated with. And I do know those numbers pretty well.

I think the important point, though, is more students do go to college and get some college and more students do graduate from college as a percentage of our population than probably any other nation in the world. That's a competitive advantage. We ought to keep it up. We ought to emphasize it even more.

And for graduate school, I can tell you the pressures to get in from overseas are pretty high. We admitted about 200 graduate students this year from all countries of the world at Cal Tech. Probably half of them American. We had 1500 applicants for graduate school from the People's Republic of China alone. And that pressure is across academia. We have to be very, very selective. But you can imagine, given the small percentage of the population that even goes to college in the People's Republic of China, these are pretty impressive students. And they will either stay in this country and add to our intellectual capital or probably some of them will stay in this country for a while and learn our ways in corporations. And then they may go back to China and they may even work for an American company in China as that company opens up to foreign goods.

So there are a whole host of competitive issues here that I think this group around the table ought to focus on. It's not necessarily just the first job out of college, which I think sometimes some members of Congress may focus on in making policy for the nation.

With respect to global competition, will it lower our salaries if every country gets good at using computers? Yeah, sure. We had the highest standard of living in the world. If we want other countries to be able to buy our products, let's hope that they will get good enough to make a decent standard of living and be able to buy our product. I think Henry Ford's motivation for paying his workers more was so each one of them would have enough money to buy a Ford. And that's not such a bad idea even today.

But will it necessarily lower our standard of living? Not if we stay ahead of all of the rest. And that's a very important issue of competition as change takes place. It's harder to stay ahead of the rest in automobiles, because they're not changing so fast. It's easier to stay ahead in computers, because they are changing rapidly. And there are some lessons there in a whole host of fields for the country.

And, finally, on empowering the workers, I agree that job security is an important issue. I didn't talk about it, because I think other people later on are going to talk about it. It's tough if you have to compete against products in a free market from around the world and wage rates are different in one part of the world than the other. And I don't have magic answers to that problem. I think these are tough issues.

And the out-sourcing issue is again a tough issue. And as far as letting the workers have the decisive power about out-sourcing, it seems to me that they should have a voice, but not the decisive power, because the corporation serves its employees. It serves its customers. It serves its stockholders. And it has to make judicious choices about how to serve all of those. And hopefully management and the board of directors are making some of the right decisions.

I have been on boards where the wrong decisions have been made and some of the management had to be changed. It's an issue to try to get the very best management. I couldn't agree more. When we're looking at how corporations and how the economy functions, good management is a very important issue, a part of it. And the good management has to motivate the worker. It actually should stimulate the worker. It should motivate the customer, so the customer will enthusiastically embrace its product or service. And it must satisfy the stockholder. It must make a profit or it will go out of business.

So there is a group of people that the board of directors has to look to. And perhaps sometimes some of them get more voice than others.

## The Implications of Technology Growth for Workers

DR. BURTLESS: I'm glad to speak to so many people who already know what I'm talking about. But I prepared my remarks under the assumption that at least a handful of people may not be aware of some of these facts. As I understand it, my job is to start a discussion about the implications of technology change for workers. And this unfortunately makes it imperative for me to make some predictions about the future.

Most people's predictions about the future are based solidly and myopically on what has happened in the recent past. And I will not disappoint you. That's what I'm going to talk about. In this honorable tradition, I am going to try to interpret some of these trends as they relate to workers and technology. I want to focus on two labor market developments, the first is what has happened to relative wages in the United States and the second on what has happened to the relative intensity of use of different skill classes of American workers.

These trends lead naturally to questions. First of all, does it appear that the work force has the skills necessary for the nation as a whole to be competitive in 20 years time? And if it doesn't, what could be done to ensure that the work force develops those skills? I see a lot of straws in the wind suggesting that skill deficiencies are a real problem in the United States, particularly for workers with limited skills and even those with mid levels of skills.

Earlier this week, I asked my research assistant to tabulate wage statistics on the very large census files that the Bureau of Labor Statistics assembles every March in order to see what's happened to relative wages in the United States. I asked her to calculate real annual earnings of every adult between 25 and 64 years old, who worked full time year around. And I then asked her to calculate what are the real earnings of these people at selected points in the wage distribution: the very bottom, at the fifth percentile, at the 10th percentile, at the 25th percentile, and so on.

The top chart that's been handed out to you [see charts at the end of this contribution] shows what these trends have been for men in the United States. And you can see in this diagram that at the bottom of the wage distribution, there's been a remarkable fall-off on how much men can earn. Earnings have dropped almost 30 percent for men at the fifth percentile of the distribution. Meanwhile, they've climbed a little faster than 10 percent over the two decades from 1973 to 1993, up at the 95th percentile. But, still, it's quite noticeable that everywhere in the bottom four quintiles, the bottom 80 percent roughly of the males' earning distribution in the United States, people are not earning as much in gross earnings as they were 20 years ago.

For women you can see on the next chart that the trends are a lot more optimistic. Earnings are up everywhere in the women's distribution, above maybe the 20th percentile or so, although they're up only a very small amount toward the bottom end. Earnings have only declined among women who are at the very bottom of the female earnings distribution.

Two things stand out in the statistics and in other statistics that I haven't brought for you. First of all, for the great majority of men and a substantial minority of women, wage improvements were even slower or wage declines were even faster since the beginning of the 1980's than they were in the much maligned 1970's. So the notion that the United States has had a tremendous resurgence in its productivity is not reflected in the earnings statistics for most American workers. They do not look like they have enjoyed the benefits of this small acceleration in productivity improvement that we've seen in the last 10 years.

Second, the trend toward greater labor market inequality actually has accelerated in the last 10 years or 12 years. It has not slowed down. It has picked up speed.

The next chart shows the link between growing earnings inequality and growing wage premiums for workers who have advanced levels of skill. This third chart shows what the earnings of workers in

different skill classes are in comparison with male wage and salary workers. At the top is the ratio of earnings of someone who has a degree beyond college in comparison with a college graduate. And you see that's marched steadily upwards since 1969. For people with schooling attainment below college degree, there has been a substantial fall-off especially since 1979. As recently as 1979, high school dropout males earned 60 percent of the wage of college graduates. And now that's dropped to just a little bit over 40 percent.

The next chart shows that these trends are quite similar for women, a little bit more erratic perhaps. But since 1979, in fact, they looked quite similar.

Some people claim that these trends can be explained by the influence of international trade. Chart 5 tries to shed light on that question. What I have done is divided U.S. industries into three different classes; those that are most intensively connected to international trade, those that are the least affected and those that have some intermediate connection with trade. This just shows what's happened to relative wages over time in the industries least influenced by trade and those that are most influenced by trade.

What this shows is the ratio of earnings in each of the years shown here between someone at the 90th percentile of the wage distribution in that industry and someone at the 10th percentile of the wage distribution. The gap between these two is a simple, easily understood measure of the difference in wages. As you can see, there has been a sharp increase, both in those industries that are highly influenced by trade—that's the lower line—and those that are in the industries that are least influenced by trade. There is no evidence that being involved in trade has had any special effect on how fast the disparities by skill class or by skill level are widening. They're widening everywhere in the United States economy, not just in those industries that are most influenced by what goes on in China or Mexico or Germany or Japan.

A natural implication of this is that as workers have been forced out of the trade-affected industries, they have been forced into less trade-influenced industries. So people have moved from industries where income disparities are somewhat lower into industries in which income disparities are somewhat higher. But most economists, looking at the statistics, agree that that shift of workers from one kind of an industry to another is not the main reason that skill premiums or the inequality of wages have been climbing. Instead, there has been a sharp increase in inequality within all of the industries in the United States.

What has caused this sharp jump in wage inequality within all of these industries? Is it technology? Is it a change in the norms or the rules that determine wage setting in the United States? The literature that's developed on this among economists over the last 7 years or 8 years is huge and it's growing very fast. I'm sorry but I'm going to have to burden you with some of the findings from this literature.

When most economists look for an explanation for the trends that I just sketched or described to you, they naturally tend to look in areas that they're familiar with. I once heard the Nobel prize winning economist, Robert Solow, describe an economist as a parrot who repeats over and over, supply and demand, supply and demand. I am a parrot trained by Robert Solow, so that's the first place I look. It's the first place that many economists look. What can we say about the relative supply and demand of different classes of workers?

The fact of the matter is the supply of skilled U.S. workers, measured by their educational attainment or measured by some level of occupational qualification has been going up. It has not been shrinking as a common indictment of the U.S. labor force might suggest. We have a higher fraction of high school graduates in our work force all of the time. We have a higher fraction of college graduates. We have a higher fraction of people with intermediate levels of qualification and indeed with advanced levels of qualification. We do not have a work force that is shrinking, that is declining in its average skill level.

Now, there is some sign that at some levels of the work force, the rapid improvements in the skill level of the U.S. work force slowed down in the 1980's, not because the cohorts of youngsters graduating from high school in the 1980's were less likely to go to college. On the contrary, they were much more likely to go to college or return to college after they had been in the work force for a while.

Instead, of course, the cohorts entering in the 1980's and the early 1990's have been smaller. And so because they're smaller and they're bringing these additional qualifications to the work force, they don't account for such a rapid growth in skills as we saw, for example, in the 1960's and the 1970's where we had generations where everybody in those cohorts practically had a high school diploma, and 20 percent to 25 percent of them had college diplomas. And they were replacing retiring cohorts of Americans who received their schooling in the 1920's, early 1930's, and had not got nearly as advanced an education. So there was a slowdown in the rate of increase in skill acquisition in the work force. But that is not the same thing as saying that the skill level of the U.S. work force has actually shrunk. It hasn't.

So this naturally causes economists to look under the other lamp post for the key, and that's the demand explanation. That is the explanation that most economists believe is the correct one.

There has been a shift in the nature of demand for workers, which has favored the workers who have acquired the most advanced educational credentials or have got the best occupational preparation. Or, more precisely, there's been a sharp decline in the demand for workers who have limited educational qualifications or occupational qualifications.

Most of this is a result of what is happening inside the firms. There has also been a shift between industries, but that shift between industries has not caused such a dramatic increase in the demand. Instead, it looks as though within most firms, there has been a tilt in the demand or an acceleration in the increase in demand for workers with more advanced skills.

Part of the reason may be the nature of the equipment that is being used in production. The personal computer, for example, has been shown to be highly favorable to workers with more general skills. It may be because of the influence of international trade, at least for some of the industries. Or it may also be because the technology of managing, organizing and owning U.S. companies has changed.

So that, unlike the 1960's and the 1970's, when company managers had a lot of latitude and felt as though their main job was to make their companies bigger, nowadays every manager in the United States realizes that if they are not earning as high a rate of return as is absolutely possible, they can be removed from their job by an unwanted take-over. For example, a company like TWA knows that it can get stewardesses and baggage handlers at $7 to $11 an hour and has no necessity of paying these people the equivalent of $20 or $22 an hour. If an airline manager doesn't behave in that way, even if there is no change in management, as there was at TWA, he realizes that if he doesn't behave that way, he can lose his job which causes him, of course, to behave in the same way.

That's not a technology explanation as it's popularly understood. Most people think of technology as simply being the machines that workers are using and the level of qualification necessary to run those machines. This is a different kind of a technology. This is the technology of organizing and managing companies. And the people who have been favored by this kind of shift in technology are people who bring a lot of skills and who have skills that are very difficult for people to replace and are skills that other firms are willing to bid for, thus raising the wages.

What factors might cause the U.S. system to short-change so many workers with limited skills in the United States? First of all, it's widely acknowledged that secondary school graduates in the United States enter the labor force with substantially less academic knowledge and proficiency in math and science than their counterparts do in other countries.

This is a country where only slightly more than half of 17-year-olds can convert nine parts out of ten

into a percentage. That's not a terrific recommendation of the schooling that most of our secondary school students receive. Incidentally, I don't think that there is a problem with K through 12 education as we heard earlier. It's much more of a problem that shows up later on, because the gap between American youngsters and their overseas counterparts are not nearly as large when they're 10 years old or 11 years old as when they're 17.

Once you get beyond age 17 or 18 for the people who go to our best 4-year colleges, they get an education that is outstanding by the world's standards. About a quarter of the work force will complete that level of schooling. That leaves three-quarters who will not complete it. Roughly half do not get work force preparation that is as good as our most effective competitors; for example, Germany, Japan, and France.

Also, not much is done for these workers after they graduate. My last graph, chart number 6, shows the public investments we make in the United States for workers whose schooling attainment ends at different levels. Each bar represents the total that is publicly spent on the formal schooling in the educational system for workers in these different final levels of schooling: school dropouts, people who get exactly 4 years of high school, and so on.

The lighter part of the graph shows the part that we spent publicly on manpower training programs, job corps, job training partnership act and other similar kinds of programs. The lower your level of schooling attainment, the greater is the proportion that comes from these kinds of manpower training programs. But that manpower training investment is nowhere close to the amount of formal school investment that we are publicly putting in people who get higher levels of schooling.

Someone who has four or more years of college receives the benefit of $24,700. This was in the late 1980's. I'm sure the numbers are greater now. Whereas the person who is just a high school dropout gets the benefit of $5520 total combined for manpower training and formal education.

Is there some other place that these people who have less formal schooling might get training? The natural place to look is within American firms. Unfortunately, everything that we know about how American firms invest in their workers suggests that the pattern for public support would be duplicated exactly by American companies. They invest more in their college graduate workers than they do in their high school dropout workers and their workers who have just a high school education.

When you put these two kinds of investment, one on top of each other, the public investment and then the company investment which occurs after people enter the labor force, we have a dramatic disparity in the level and kind of investment that we're making in workers whose formal schooling ends at a different point.

In other countries, the disparities are a lot smaller. Even Japan, which is as capitalist as the United States and which has as small a public budget as a share of national income as we do, the degree of equality in this kind of investment would be much greater than it is here in the United States because of the very large investments that Japanese firms make early in the careers of their high school graduate workers. In Germany, because of the combination of public and private apprenticeship system that they have, there is a lot of investment that goes into the school dropouts and the people who have completed secondary schools, but who do not go on to the formal schooling system.

What are the implications of technology for the work force? For the top one-third, the system is working beautifully. Their wages are climbing. They are the beneficiaries of this large public investment. They're the beneficiaries of large private investment made by themselves and by their employers. Things are going beautifully. And I think an argument could be made that the United States, for those workers, is doing a better job than any other industrialized country.

Unfortunately, that leaves two-thirds of the workers out in the cold, relatively speaking. We have to think very, very hard about the institutions that we have for educating these people at the end of their

secondary schooling to make them the equivalent of workers in some overseas competitor countries of the United States, where that kind of preparation is just a damn sight better than it is here in the United States.

MR. YOCHELSON: Dr. Burtless, thank you very much. May I take this opportunity to welcome Deputy Secretary of Commerce, Dave Barram. And, Dr. Burtless, you raised a range of issues pertaining to industry and what you referred to as the technology of management, as well as to public policy. Dr. Prabhakar has reminded me that we have not heard as much yet in the day from industry as we might. On that note, I open the floor.

MR. SALDICH: I want to start with a quick question. With respect to chart 1 and chart 2, have you run the same numbers for countries like France, Germany and the United Kingdom? Do you know how they would stack up on that measure?

DR. BURTLESS: In France, there has been very little change in the distribution of hourly wages over the last 12 years. In Germany, there has been more, but not nearly the same amount that there has been in the United States. And in the United Kingdom, there has been more than there has been in Germany. In Europe, the United Kingdom is probably closer to the United States in replicating these kinds of numbers, although it should be emphasized that in the United Kingdom, charts 1 and 2 would not show people with a 30 percent decline in their real annual earnings.

Canada is the most similar to the United States. But even in Canada, the shrinkage in earnings of workers toward the bottom has been significantly smaller than in the United States. So the United States has seen the biggest increase in these kinds of skill premiums and relative wage gaps of any of the industrialized countries. I'm not arguing, incidentally, that France and Germany do not face other kinds of problems. But the fact is that on this score, the United States has certainly been the extreme performer.

MR. WILLIAM ARCHEY: I would just make a couple of observations and then ask Dr. Burtless a question. I represent a high tech industry. About 3 years ago, we engaged in a major study of what are the skills needed for three kinds of workers, a worker in a high technology assembly line, a sales worker in a high tech industry, and an office manager. The study was funded by a grant from the Department of Labor, and those were the days when business and government cooperation was not considered an ideological mortal sin.

It's very interesting what happened. My colleague at the National Association of Businesses is still involved with this study. There were about six different industries that were in fact studied. I think, Mr. Oswald, your group was involved with some of the study.

The report got an awful lot of attention, because people felt that it passed the feel and smell test, that it made a lot of sense. We discovered that the skills necessary to perform well in these high tech industries were not the skills that were being taught. We are now doing pilot studies with community colleges and with high schools. What we're discovering is an enormous resistance, particularly at the high school level, of fundamental changes in the curriculum to beget the kind of skills enhancement of students that they really need; less resistance at the community college level, but still some resistance there. I agree with Dr. Everhart that the community college is probably one of the real potential jewels in dealing with this issue as far as an institutional locus.

The other point is when it comes to doing it, the industry that I represent has in fact been very much at the ramparts on this issue. Hewlett-Packard spends probably a couple hundred million dollars a year on direct training, education, and remedial training. About 2 years ago Motorola spent about $82 million on just remedial math and remedial skills training for workers.

We're discovering that despite knowing pretty much which skills are needed the institutions are not so gung ho about changing.

One of the things we're dealing with is high school students competing with high school student from Hong Kong and Singapore. We are dealing with literally an international marketplace and we still believe in that incredibly important idea in American education of local control of schools. If we're going to do something dramatic that deals with this issue, the issue of local control of schools has got to be put on the table. Nobody wants to talk about it.

MR. WILLIAMS: First of all, a quick commercial. All of those other countries you're talking about have more unions and more collective bargaining going on than we do in the United States, with the possible exception of France which doesn't have as high a percentage of unionization even as we do, but which has a very public way of bargaining as we've been reading about every day.

I believe very much in training and education. I'm totally committed to it, trying to do a lot of work in that regard over the years, have tried to think a civilized society should be doing that, should be providing education and training to the maximum of the capacity of its citizens regardless of the economic implications of it. So I have no question about the importance and the significance of education and training.

But I do want to ask you a question as an economist about whether you're really saying there is a supply side solution to this problem. I've had this concern all along as we promote training and education. But whether what we're really saying is that if we go out there and we educate and train all of these people better, that automatically these numbers are going to move up for everybody. And I wonder about that a lot just in terms of common sense, particularly when I see things like the beginning of the current administration. One of the first good ideas that went down the tubes before the administration even took office was the idea of a training tax. It would require all of the employers to either train or pay a tax. The tax was 1 percent or 1.5 percent. That disappeared so quickly that it's difficult now to remember that it was out there as a serious idea.

Small and medium sized businesses are reluctant to move into higher technologies. They are opposed to this training tax which says we can't begin to afford to do any of these things. If they felt some need to do it in economic terms, surely they would be more sympathetic to having it done. Indeed the more advanced of them, one would think, would have some kind of a community interest in requiring everybody in this society to do that, so you don't steal each other's trained workers.

My question is, do you as an economist, or do the economists for whom you're speaking, generally see a supply side solution to this problem, or are there other kinds of interventions that we need in terms of providing a much broader range of opportunity for American workers?

DR. VICTORIA F. HAYNES: My comments will build on the comments of the other two, although they weren't planned. We've talked this morning about the problems that technology brings including the knowledge economy and loss of jobs. Being a technologist and when presented with a problem, I always look at this from the standpoint of what can technology bring in terms of solving the problem.

There are two issues we should be addressing as a group. One has to do with the demand side. That is, how do you create better jobs, more of them, in the kind of global economy that we're working in, and, specifically, more in the United States. We shouldn't overlook some of the comments that Mary made earlier. That is, that you have to create demand by using technology to enable our industries, whether they're small, medium or large, to produce the kinds of jobs that provide a higher standard of living, higher wages for people within this country. That's number one.

The second concerns what technology can do to enable training and education. We're talking about information systems and about access to all types of technology anywhere in the world. And yet we have not addressed how we can use technology to solve some of the problems that are a result of technology development.

DR. HERMANN: My question, Dr. Burtless, is what might we do to correct this disparity. I'll lead

by saying that we have put a lot of the power to create in the corporate hands. We need to do something about the salary disparity as corporations. As Mr. Williams indicated, when the time comes economically, small and medium sized companies will do that for their own selfish corporate reasons. We have been slow to do so. Some companies like Motorola and Hewlett-Packard are exemplars of investing in training. They are being repaid in the marketplace for their investments.
In due course the mechanism of the private company, will make some contribution to changing the education system, including continuing education throughout the life of an employee. We will cause some competition between locally dominated, locally controlled school systems by choosing where to locate in part on the basis of good students. In a modest sense, there is a competitive aspect that will cause Arizona to try to do this and North Carolina to try to do that. So it's not clear to me that a national solution is an absolute necessity, although an average national solution is required.

There are some things that are occurring within corporate governing structure. But aside from that, do you have recommendations as to models that we might come to agreement on and pursue as a product of this dialogue? Thank you.

DR. CHIMERINE: Even if Dr. Burtless' conclusion is right, that income disparity has not worsened because of trade or global competition, there is still the distinct possibility that the general reduction in the growth of real incomes across the board has to some extent been caused by large, structural trade deficits in the United States.

In fact, even in your numbers, Dr. Burtless, at the upper ends, perhaps with the exclusion of the top 1 percent, even though earnings have grown over the last 20 years in real terms, those are not large increases relative to what occurred during the prior 20 years. So it's still reasonable to assume that trade related impacts on the wage structure of the United States are not insignificant. They may not be dominant. They may not be causing much or all of the increase in income disparity. But they are affecting the wage level in the United States to some degree.

We talked earlier about the level of saving and investment in the United States, and that in the long run, if we want to increase productivity growth, we need to save and invest more. And hopefully through the market mechanism, this will translate into faster growth in real earnings.

But it seems to me that's long term. That may or may not happen. But isn't the bigger issue the composition of investment? Aren't we all saying that because of the tax system, because of the reward system, perhaps because of the influence of Wall Street earnings expectations and other factors, that a significant share of our investment may not be going in the right place. That at the corporate level, it's too much towards short term payoff kind of investments, mergers and acquisitions, and not enough on the long term R&D and training programs that, again, have a very long term payoff.

From a more macro perspective, too much of our investment dollars is going into real estate and stock market speculation, and not into the kinds of investment that stimulates long term productivity growth. From a policy perspective, if that's the case, we have a better chance of shifting the mix over the next 5 years or 10 years than we have in making a dramatic change in the level of saving and investment.

MR. GARY BACHULA: I'd like to add another issue or two to this discussion of the work force in this new knowledge based economy. It's clear that education and skills are the primary issue, but it's not the only one. As we look at what's happening in this new economy, mobility/flexibility of the work force is also merging as a very major issue. The idea that you would graduate from high school or college and affiliate with a company for a 40-year career and then retire is literally gone today.

Successful workers are not only going to be those who are better educated and better skilled, but who are also mobile and flexible. And that raises some questions about the institutions that we have in place to allow that worker to be mobile and still be secure. It requires us to think about portable pensions. It requires us to think about portable health care. And it requires us to think about portable life-long learning institutions, because, again, one company may not want to train you if you're going to be able

to move and go to your competitor down the road.

When we moved from an agrarian economy to the industrial one, the political systems developed new institutions to cushion the impact and enable the industrial economy to work, whether it was minimum wage in labor laws and social security or child labor laws or whatever.

There are going to be new institutions to make this knowledge based economy work. It does relate to portable pensions. It relates to health care and it relates to this life-long learning mechanism. It may mean that there are new kinds of groups that will have to emerge. There may be a new role for the labor movement with less bargaining on wages. But representing millions of people in terms of their pensions, in terms of health care, in terms of life-long learning and training. And that may be a new direction. Professional associations may take on new kinds of roles.

Colleges are going to start offering contracts that go beyond the four years and that literally give you a life long connection in which you go back on a regular basis to talk to the faculty, to access the library, to get weekend learning on the latest thinking in your area. You'll be going back to campus a lot more than just simply for football games and for reunions. But you'll be doing it in a variety of ways that will be enabled by some of the new information technologies.

So the debate goes beyond just the absolute level of education and training. It has to include the institutions that deliver education and training throughout a life, as well as portability of pensions and health care.

MR. PATTERSON: High schools are not delivering on the contract that they have to produce. Currently the high school diploma does not ensure that the students have adequate skills in English and Math.

The leading companies are spending a huge portion of their budgets to bring people up to a true high school level of education so that they can be in self-directed work teams and learn new concepts and new skills sets. But they don't have the basic skills coming out of high school.

How do we get the secondary school system to produce a specific level that would enable companies to build on a high school diploma, rather than starting and spending several years getting them up to.

DR. PHILIP BRODSKY: Many American companies, including my own, have policies that when we build a plant in another country, we maintain certain standards the same as or, at least as good as, our American standards in areas such as safety and industrial hygiene. That frequently involves extensive training of workers who may not have even the hygiene standards in their own homes that we want to maintain in our plants.

Looking at that in reverse now, as more foreign companies are setting up plants in the United States and in fact whole towns are now being dominated by Japanese assembly plants, I assume they are bringing some of their training practices to this country.

What we have seen as an American company is when we set up high standards in a foreign country, we tend to change the patterns in that community. People want to come to work for us. And pretty soon, the competitive local companies have to start raising their standards.

Are we seeing that happening in towns that are now dominated by foreign companies where they may be increasing their training standards or other standards for how they educate workers; and is that starting to spread now to American-based companies?

DR. BURTLESS: As the brother of a member of the United Steelworkers, I will answer Mr. Williams' question first, because it's a very fundamental question that is always asked. If you build it, will they come? If you increase the skill of the bottom third or bottom two-thirds of the U.S. work force, can we

be sure that indeed firms will start to use high performance methods, higher productivity methods in the way their companies operate?

I don't think we have any clear answer. We know that relative supply does seem to affect relative price. In the 1970's, there was a dramatic increase in the proportion of young entrants into the labor force, people between the ages of about 20 and 35, who had a college degree. There was an equally startling decline in the relative wage received by these young college graduate workers. The relative wage of the highly educated workers fell relative to that of the high school graduates or even the high school dropouts. So relative supplies do seem to have an influence on the price.

Now, lurking behind your question, I detected anther kind of a question. And that is, is there some other source of greater wage disparities in the United States that isn't accounted for just by the relative skill of workers. And I think you're right. There is another source.

By training more workers to a higher level of skill, perhaps we can go toward the wage distribution that Germany has, which is more egalitarian than the wage distribution we have here in the United States. But I don't think it's going to take us all of the way, because we have many other institutions in the United States that ensure that fairly wide wage disparities will remain.

Briefly, the answer to your question is, yes. Increasing the supply of highly skilled workers or people with good medium levels of skill will indeed raise their wages.
Dr. Hermann said that there are some things happening right now that are going to reduce wage disparity. Some day, firms are going to have to invest a lot more in training their workers. Some day, they will start to locate in areas where the skilled workers are relatively abundant. I wouldn't hold my breath.

When you think of the story of industrial location in the United States, a lot of the footloose industries have gone to areas not where workers with high skills are abundant, but where workers with low skills are fairly abundant, to take advantage of the much lower average wages in those sectors. The success of North Carolina and South Carolina in attracting so much manufacturing is not attributed to the terrific educational systems in those two states. It's attributable to the low wages in those two states.

Also, if firms have opportunities to locate in other parts of world where wages are much lower and where skills aren't necessarily very much lower, they may choose that rather than to move to the part of the United States where skills are very abundant. There is an important exception to that, and that is, high tech industries. They do certainly tend to locate where very skilled workers are abundant such as eastern Massachusetts and California.

I do not see any forces on U.S. companies that are going to make them invest in their less skilled workers when it's so easy to avoid that obligation, which is precisely what on average they're doing.

Someone asked me, what would I do to reduce these disparities in training investments. I wrote a book with a couple of my colleagues. Now both of them are in the administration. It's called Growth With Equity, in which we talk about mechanisms to boost investments that have high long-term pay-offs. One of those was investments in less skilled U.S. workers.

Our suggestion was a training tax that firms could avoid by investing themselves in their less skilled workers, because the demand for workers with better skills is not so powerful that it will offset what is the companies' main focus, which is on their own business. The history of the relationship between most U.S. companies and most local U.S. schools does not suggest that firms are ever going to make big investments in maintaining close relationships with those schools to try to make them improve.

In the mid 1950's, businesses in the United States and homeowners paid the same property tax. If you look at the latest national income and product accounts of the United States, you'll see that businesses now pay half the rate of property tax that homeowners do. The main reason for that change is that

businesses located in areas that will give them tax breaks. Businesses are not even paying property taxes, which is the main source of financing for schools.

To expect businesses to maintain costly and time consuming relationships with the local schools to improve their output of trained workers is just not very likely. Businesses have other things that they want to focus on and the level of preparation of a handful of graduates that they might hire next year is not high on their list when they can recruit workers or locate their businesses.

It's widely believed in the United States that there is much less job stability than there used to be. But the statistics don't support that view. There is one group in the economy that has less job stability than it used to have, and that is the least skilled workers. For people with average skills or above average skills, there is no evidence whatever that careers in a firm are shorter than they once were. Workers have the same job tenures that they used to have.

What's changed is the penalty for losing that job. The penalty for losing a job nowadays, if you have gotten halfway up the career ladder, is very big, because for most workers who have inched up the seniority scale with their employer, to lose their job, their next best job involves a very substantial loss in earnings, especially for people with only moderate levels of skill. It's that penalty that is making workers a lot more nervous. It's not the actual increase in turnover in the labor force. Only for the least skilled workers has there been an increase in the turnover rate.

So I certainly favor life-long learning in any kind of institutional arrangement. My guess is that the best mechanism to achieve life-long learning in the United States is to increase the incentives both for workers and for their employers to invest in that activity. And for employers, the incentive to invest in the skills of their least skilled workers is very low.

I hear the remark that many companies are making big investments in these least skilled workers. When I say that the investment that companies make in their workers is strictly proportional to how much formal schooling the workers bring to their company, that's on the basis of surveys of companies and of workers. I'm sure that there are exceptional companies in the United States that don't follow that kind of practice. Maybe Siemens doesn't. But Siemens is a German company with a German culture, and perhaps that's the reason.

The dominant mode in the United States is firms invest the most in their most highly educated workers. And they invest least in their least educated workers. So all of the disparities that you see in this figure are compounded, if we can take account of how enterprises invest in their own workers. It's that culture that we really have to change through training tax or through some new kind of institutional arrangement.

MR. COATES[1]: I had a comment on Gary's material before. Unfortunately he's not here, but I think there is an error in his chart 3. If you look at Gary's chart 3, you will see that in 1969, what he is saying is that people who had degrees beyond college earned no more than college graduates. So what that suggests is there was a printout error perhaps in that whole line. But that was just a possible mistake.

But more important, aside from the excellent data he presented, it gives a muted story. It really gives a relatively blunted story of the significance of the points he was making, because he's dealing only with full-time labor. If we look at the 5 percent unemployed, if we look at part-time worker, a quarter to a third of whom are eager to find full-time work, if we look at temporary and contract workers and so on, these are all in relatively depressed positions compared to these full-time workers.

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[1]Comment given during general discussion after last presentation.

Plus, the uncertain percent, perhaps as high as 7 or 8 percent, who have simply dropped out of the labor force.

So working on full-time employed people only for earnings gives you a much more positive view of the situation than an overall view.

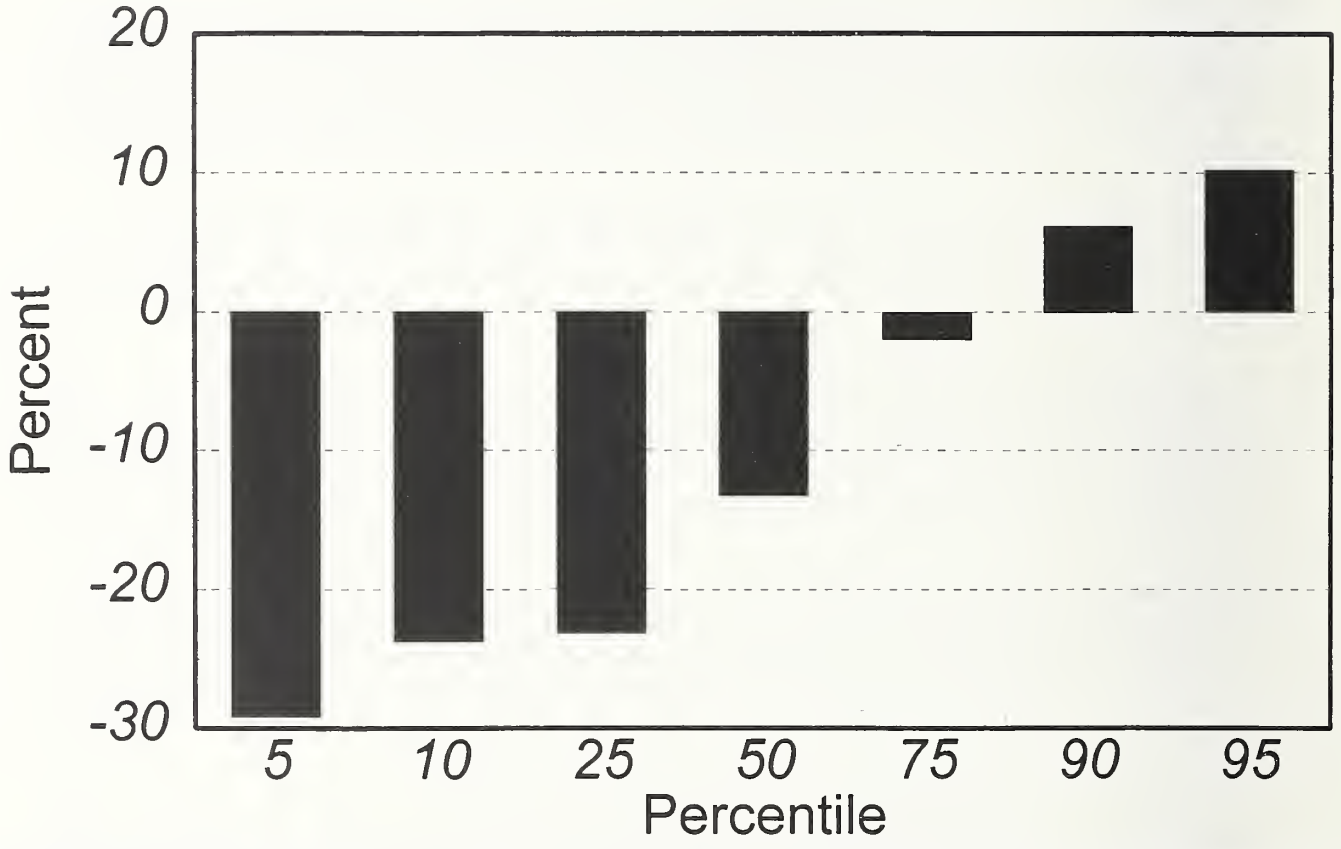
Secondly, he is presenting the data in terms of earnings. If he switches to income rather than earnings, what he would be showing would be a skyrocketing in the income in the 95th percentile, because a large portion of the income is not from earnings but from dividends. Now, the point of that is when you look at the source of those additional incomes, they are going to be connected with the multinational corporation, they are going to be connected to international trade.

So I think that we have a very nice story here, a problem that we face, but it's a much, much too muted story.

MR. BURTLESS[2]: There was no error in Chart 3. Male wage and salary workers with post-college degrees received the same average annual earnings as college graduates in 1969. Remember, many of the highest-earning males with post-college degrees, like doctors and lawyers, are self-employed rather than wage and salary workers. High school teachers, who have low annual wages, have post-graduate degrees.

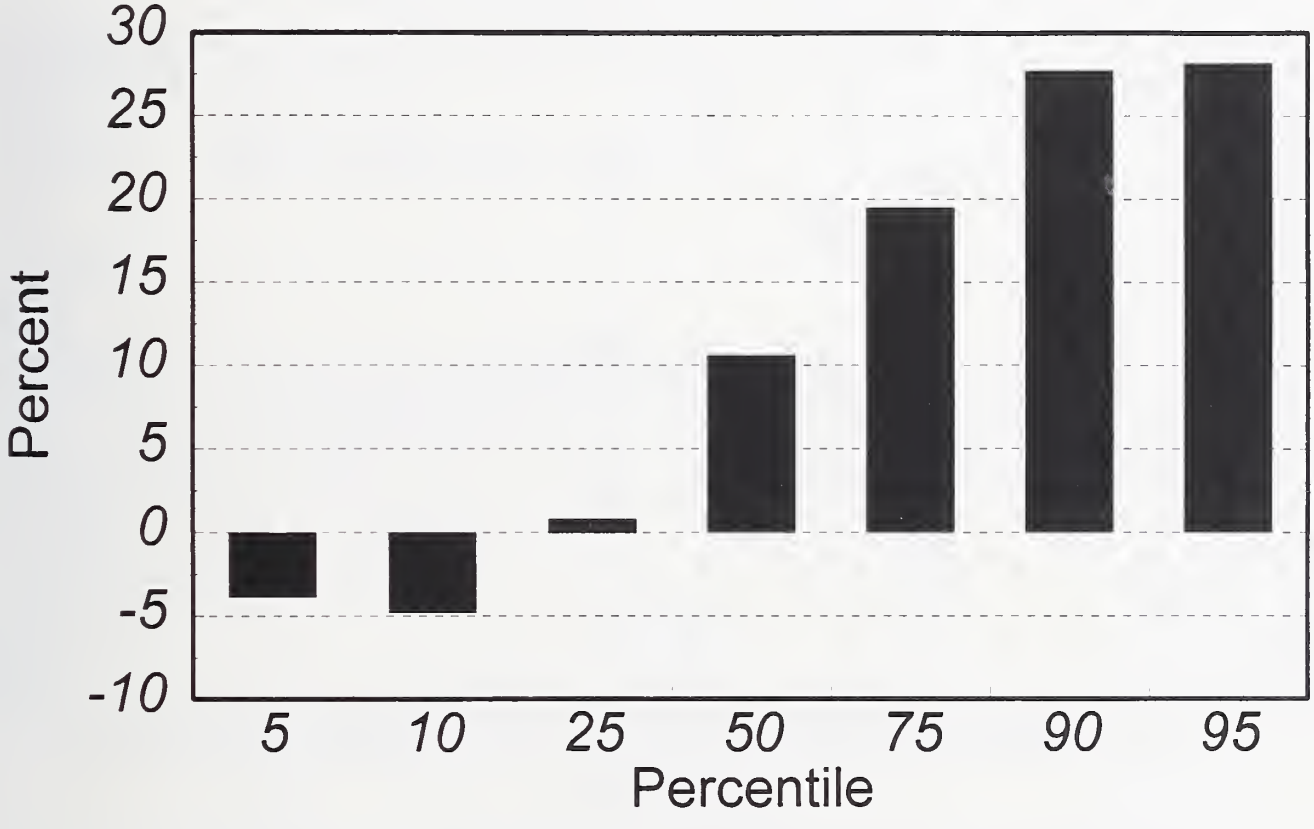
[2]Written comment supplied by Mr. Burtless after the meeting.

## Chart 1. Changes in Male Earnings, 1973-93, Full-time Year-round Workers



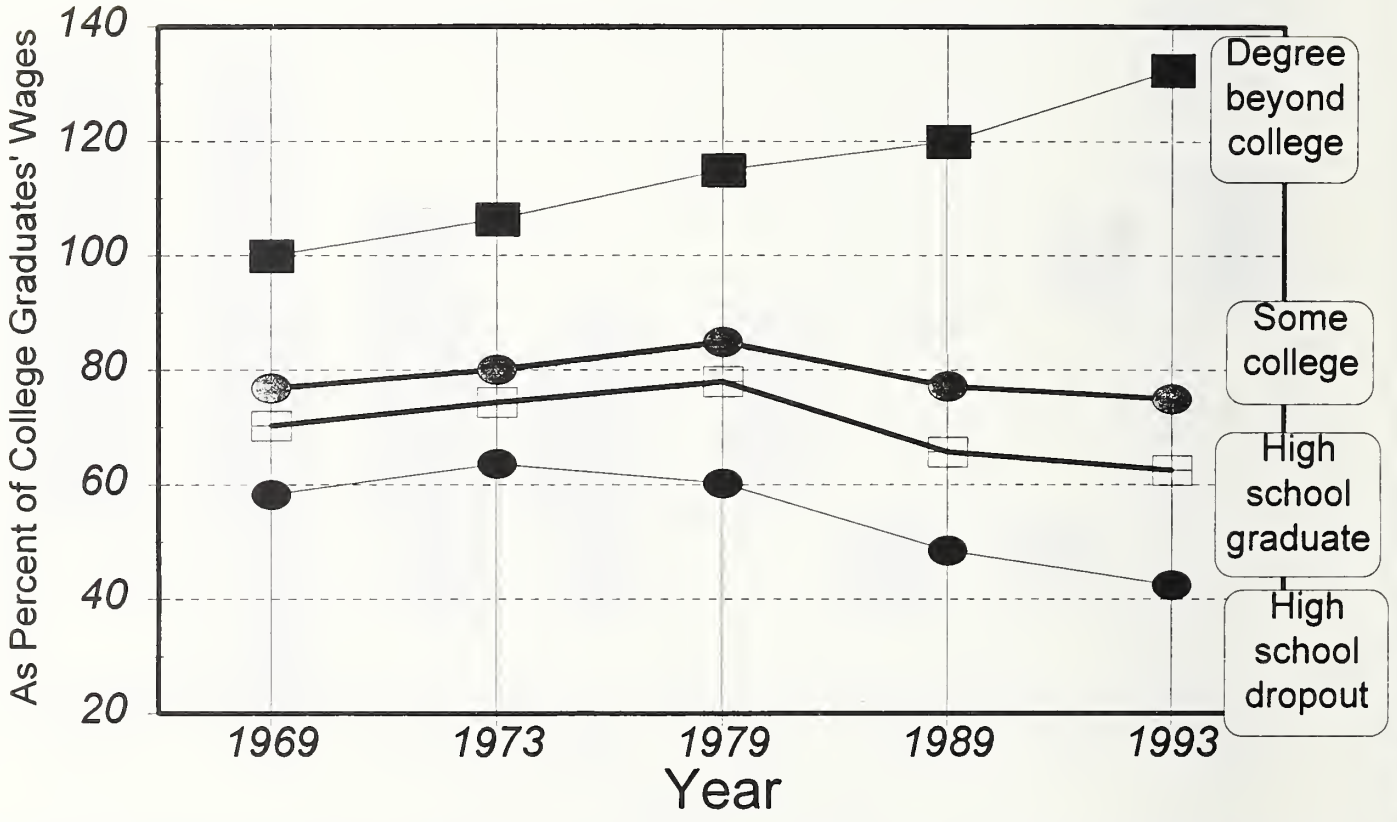

*Source: Gary Burtless tabulations of the Current Population Survey (25-64 year-olds).*

## Chart 2. Changes in Female Earnings, 1973-93, Full-time, Year-round Workers



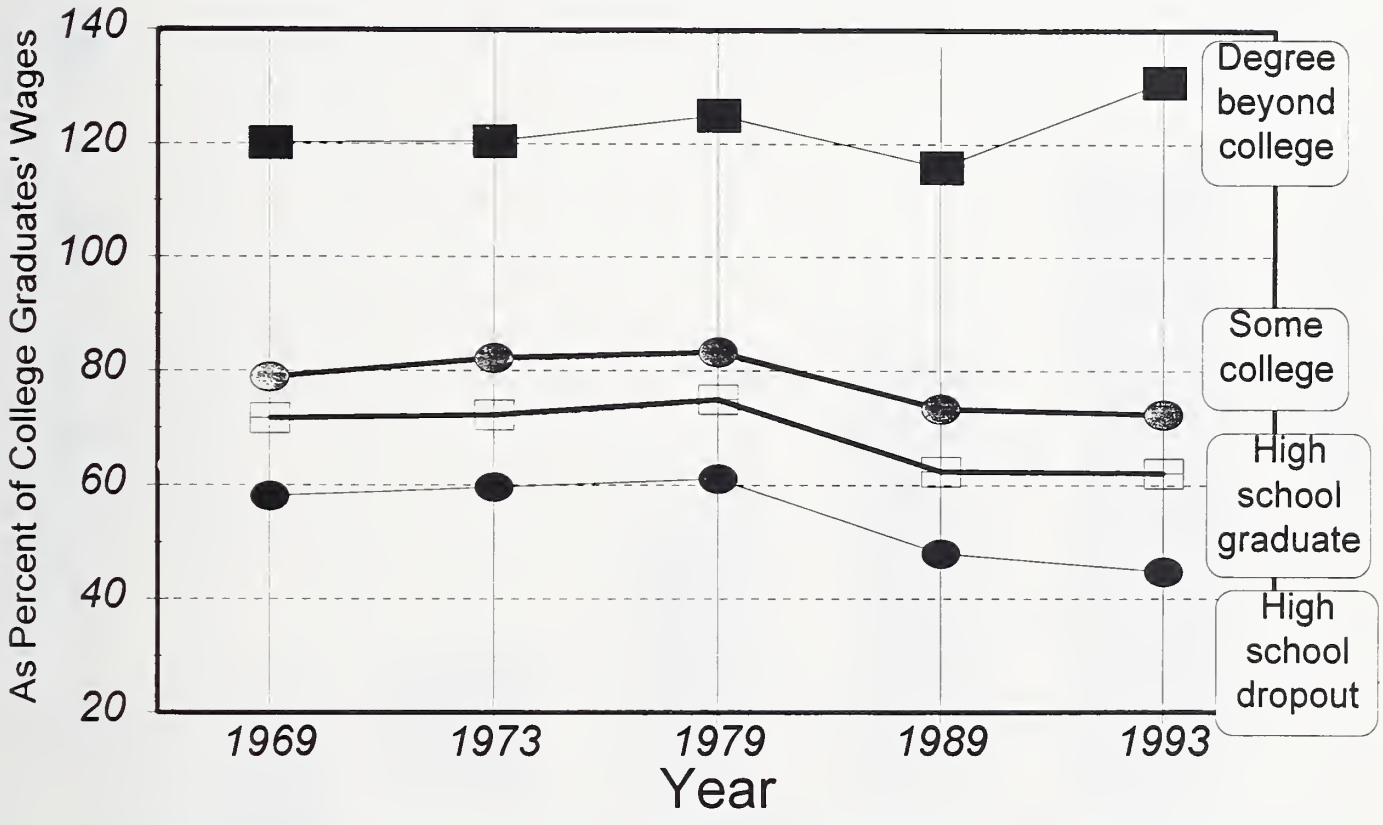

*Source: Gary Burtless tabulations of the Current Population Survey (25-64 year-olds).*

## Chart 3. Relative Earnings by School Attainment, Full-time Males, 1969-93



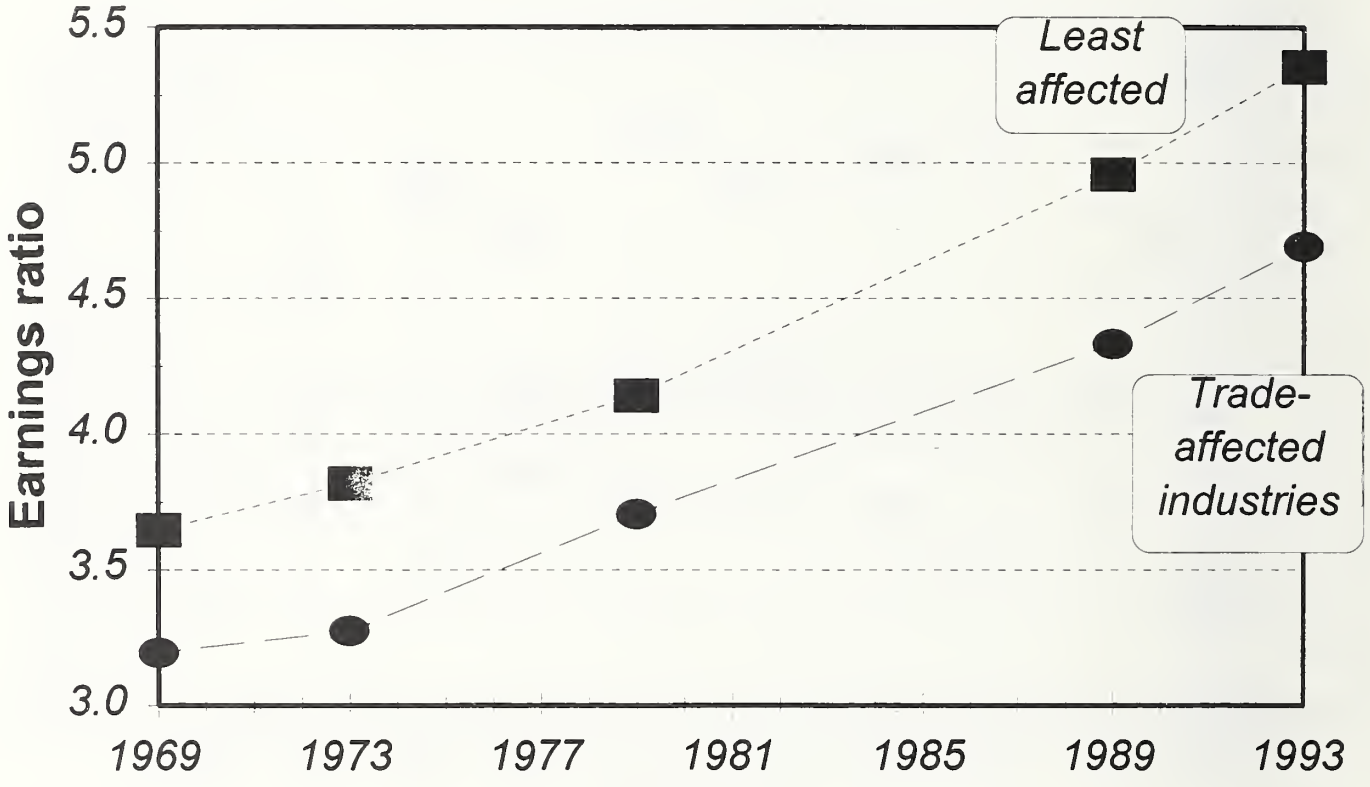

*Source: Gary Burtless tabulations of the Current Population Survey (wage and salary workers).*

# Chart 4. Relative Earnings by School Attainment, Full-time Females, 1969-93




*Source: Gary Burtless tabulations of the Current Population Survey (wage and salary workers).*

## Chart 5. Ratio of Earnings at 90th Percentile to Earnings at 10th Percentile, 1969-93: Males*

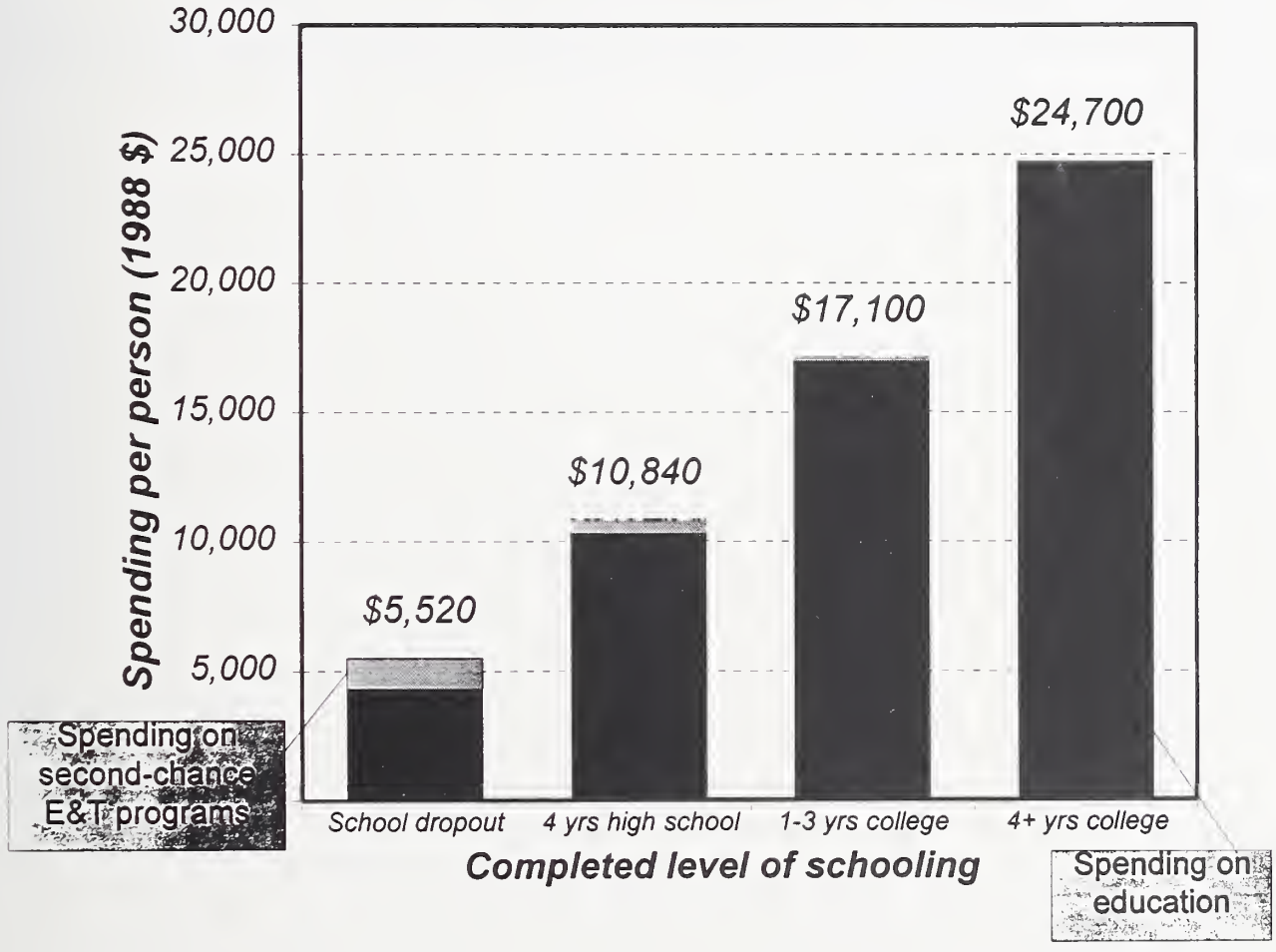



* *Annual earnings of full-time, year-round male workers.*
*Source: Author's tabulations of the Current Population Surveys.*

## Chart 6.

# Cumulative Public Spending per Person Aged 16-24 on Education and Training (Excl. Tax Subsidies to Firms)

| Completed Level of Schooling | Total Cost | Cost of High School | Cost after High School |
|---|---|---|---|
| High School Dropout | $5,520 | $3,800 | $1,720 |
| High School Graduate | $10,840 | $9,500 | $1,340 |
| Some College | $17,100 | $9,500 | $7,600 |
| College Graduate | $24,700 | $9,500 | $15,200 |




*Source: U.S. General Accounting Office, "Training Strategies: Preparing Noncollege Youth for Employment in the U.S. and Foreign Countries" (May 1990), p. 24.*

## Opening Afternoon Session

DR. PRABHAKAR: Let me just say that so far in the conversation a lot of our discussion has focussed on issues of work force concerns, income gap and disparities. We've talked about education and training. I think these are all very vital areas. We have not yet really heard a lot of the company perspective from any of the company people sitting around the table. I'd like to make sure we get some of that out and into this flow of conversation.

I would comment that most of our conversations so far has been discussing the implications of the change that technology has wrought as opposed to thinking about technology, per se. That's highly appropriate. But as well, it would be valuable for us to think a bit about how we might best think of new technologies and that process in a way that will optimize our future in all of the dimensions that we've been talking about. So I think there are many conversations that we could have that point a little bit more in that direction.

We're going to turn to a session now on the implications of technology growth on the quality of life in an attempt to try to look at some of the broader aspects of quality of life.

## Implications of Technology Growth on the Quality of Life[3]

DR. MacARTHUR: The title of this conference poses a critical question about America's future prospects. That the Nation's technological preparedness is being questioned is an unsettling turnabout in our national self-confidence and our characteristic optimism about the future.

There is a consensus that the Nation must balance its budget, although there is disagreement on how to accomplish this. One would hope that expenditures for science and technology, education, health, and the environment would be considered as investments for the future and would not be cut arbitrarily. But, no matter how you slice it, we must learn to do more with less. It is urgent to find ways to produce real benefits for people and communities through better priority setting, more cost-effective management of R&D, and more collaboration and cost-sharing among community, academic, and industrial stakeholders and all levels of government.

In addressing the topic I was assigned, "The Implications of Technology Growth on the Quality of Life," I had intended to discuss the impact of managed care on biomedical research and the delivery of health-care services and the importance of preserving biodiversity for a sustainable future. But it is late in the day. So, in the interest of saving time, I will cover only the issue of managed care.

America's preeminence in biomedical research and innovative health care has been the envy of the world. This preeminence has come at great cost: it now reaches $1 trillion a year. Most people acknowledge the need to slow the growth of health-care costs and to enhance medical efficacy and cost-effectiveness. As a result, the U.S. health-care system is being transformed by legislation, regulation, and the marketplace. Unfortunately, this transformation is being forced almost solely by cost considerations. One apparent outcome of this concentration on cost is the rapid growth of medical mega-organizations that care for tens of thousands of patients.

Managed care is a health-care snowball gathering speed and weight. Managed care now covers more than half of all patients in the United States—50 million individuals—and this number is increasing by 11 percent annually. Even more dramatic increases will occur if Congress passes legislation that allows Medicare recipients the choice of remaining within the present Medicare system or electing managed care.

Managed care is answering the call for cost containment, but what are we sacrificing to achieve such savings? Managed-care organizations are erecting tough cost and efficacy criteria, which leave little room for the application of experimental medical therapies because such therapies have no track record and, most certainly, tend to be expensive. (Managed-care organizations are interested not only in cost containment, but also in maximizing profits for their shareholders.) These hurdles to innovation are already taking their toll on small companies developing new or improved medical devices and biotechnology products. Even the larger players in the pharmaceutical and biotechnology industries are feeling the pinch and are likely to reduce R&D expenditures as a result. The ultimate consequences of these market barriers to innovation will be slower progress in improving the quality of delivered care and the discouragement of risk taking by medical innovators and their backers.

As the fee-for-service system shrinks and cost-focused managed care grows, the medical-insurance industry is restructuring itself. This realignment is already shutting off the flow of funds and patients to academic health centers (AHC's). AHC's are teaching hospitals affiliated with university medical

[3]Text based on manuscript prepared for the workshop.

schools and research laboratories—such as Johns Hopkins, George Washington, and Yale-New Haven—that train physicians, develop biomedical knowledge and clinical techniques, provide unique patient-care resources, and treat many of the indigent and the uninsured. At the same time, because of budgetary constraints, AHC's are facing sharp cuts in patient fees and graduate medical education subsidies from Medicare and a reduction in highly specialized graduate research training grants from the National Institutes of Health. The country's AHC's have been a major force in making American medicine the world leader in quality. If their crucial research and education missions are not preserved, the historically rising quality curve of American medical care will flatten, maybe even decline. This is a quality-of-life issue for Americans—if there ever was one.

Managed-care firms that have reached sufficiently large economies of scale should recognize that it is in their best interest to fund their own research, perhaps on a cost-shared basis with other entities, including federal and state agencies and third-party payers. But, at present, only a few firms, such as Kaiser Permanente, Puget Sound, and U.S. Health Care, are conducting research. Although large managed-care organizations are especially well positioned to provide the patient volume for clinical research to evaluate innovative treatments and practices that may have a short-term payoff in cost reduction and efficacy, few of them show signs of committing to the often expensive application of experimental therapies or to the medical education function undertaken by AHC's. Moreover, the same competitiveness that drives managed care to large economies of scale may still leave us with a few health-care giants barring the gates to new technology not developed in house, that is, not developed by them.

The preservation of AHC's and their research and education roles in the evolving health-care industry is a major issue affecting the quality of life of Americans and requires policy development at the highest echelons of Federal and state government. An approach that should be considered is the establishment of an all-payer system, one that shares the cost of the research and education missions of the AHC's among all those who benefit from AHCs. Managed-care organizations certainly benefit from the training of health-care professionals and from clinical research that has established the value of new and/or experimental patient treatments, so managed-care organizations should also share the costs.

To maintain increasing quality in health care, the greatest pressure must come from community-level public and private agencies and from those health-care-plan subscribers who are well informed about the stake they have in adequate long-term support of medical research and education. Generating a sufficient amount of public information to spur action on such issues will require greater collaboration among community organizations and across all levels of government.

In this regard, information technology and systems have a particularly critical role to play. Information systems are needed to keep people, employers, and government informed about available health-care plans, cost, and performance, so that health-care organizations are under continuing pressure to become more efficient at a higher degree of service quality. Health-care organizations must be able to assess quality of care provided at the individual-patient level; large health-care organizations must be able to assess the quality of public-health services provided to thousands of people.

With adequate public information and effective collaboration among community groups, health-care organizations and third-party payers will also be pressed to seek new ideas and models for more cost-effective management, organization, and financing of health-care services. The development of improved systems and procedures for communication and cooperation among health-care professionals will speed up technology transfer to achieve earlier cost reductions and increased efficacy of treatment. By these means, the rising national cost for health-care services may be moderated, allowing more

resources to be directed to medical research and education. After all, although we are interested in cost containment of health care, we are also interested in the quality of health care for all of our citizens.

In summary, we must make health care more cost-effective and accessible, but, in the process, we must not sacrifice American leadership in advancing medical technology and medical education on the altar of cost containment. The survival of AHC's is critically important in maintaining the primacy of American medicine and in enhancing the skills of health-care professionals.

In ensuring the quality of life of all Americans, there is no more important issue than access to quality health care at an affordable price. To provide such health care, all levels of government, industry, academia, communities, and individual citizens must be players in establishing priorities and policies for allocating R&D resources. New systems of management, organization, cost-sharing, and collaboration must be explored. The effort required is great but well worth it.

**Implications of Technology Growth on the Quality of Life**

DR. COLWELL: Thank you. I appreciate the opportunity to talk with you.

Let me say in dramatic, but accurate terms, we are living in a revolution and have been since about 1970. Watson and Crick proposed the helical structure of DNA in 1953; the first gene was cloned in the early 1970's; and, soon thereafter, the human insulin gene was cloned into a bacterium. And, that marked the beginning of a new industry.

There was no biotechnology industry to speak of before about 1970. In 1995, there were about 1300 biotechnology or biotechnology-focused companies in the United States employing about 110,000 people. And, when you compare this with one of the largest of the pharmaceutical companies, Merck, with about 88,000 employees (now downsized to much less), it is clear that growth has been rapid. The prediction is that approximately one million people will be employed in biotechnology or biotechnology-related industries by the year 2005.

The products of biotechnology include the pomato, protoplast fusion of the potato and tomato, and the geep, a cross between a goat and a sheep. These are the more pyrotechnical developments. There are other important developments taking place in medicine. Concurrent with this meeting, a meeting on the human genome and gene sequencing is taking place nearby, presenting dramatic and very exciting findings. Having said this, I'm not sure that we, as a society, are prepared for what the future will bring, especially with the new information that will be available from sequencing the human genome in its entirety. The entire genomes of two bacteria have already been sequenced and the results published recently.

One point I wish to make is that we now can sequence the entire genomes of various human pathogens, providing by means of searching the database, the mechanism for developing new vaccines, vaccines much more effective since the external surfaces of the bacteria, e.g., the subtle structures uncovered by means of information derived from sequencing will allow more effective vaccines.

Inborn errors of metabolism will be amenable to correction by genetic engineering. The example of diabetes is useful. At the turn of the century, a child born with diabetes faced a shortening of life span and a less than optimum quality of life. By the 1930's, Banting and Best had extracted and purified from hog pancreas the insulin molecule. An injectable insulin was eventually produced that allowed diabetics to achieve a longer life and a much better quality of life. By 1977, the cloning of the human insulin gene into a bacterium was accomplished. And, now we have a recombinant insulin that is more effective in many ways.

Within a decade, a child diagnosed at birth as having a defective gene for insulin production will be able to be "cured." It is feasible that cells will be extracted from the child and the cells grown in the laboratory. The "corrected" gene, i.e., an active gene will be inserted and incorporated into the genome and these cells reintroduced into the child. Biotechnology will, thereby, be used to correct errors of metabolism.

These kinds of advances are extraordinary. In the interim, we must deal with difficult social issues; namely, the ability to learn by gene sequencing and cloning a predilection to lung cancer or perhaps to multiple sclerosis (MS) or cystic fibrosis (CF). With modern techniques, we've been able to extend life of CF victims. Without cure, the question is how to deal with insurance, health care, and other such difficult social and ethical problems?

These issues will arrive upon us faster than we would like. Pick up the Washington Post or the New York Times, and we find another gene has been cloned and sequenced and a probe prepared for diagnosis. What is portended is the practice of a new kind of medicine. Instead of treating symptoms and treating disease post-facto, being armed with knowledge of susceptibility to a given cancer, by modifying one's lifestyle and avoiding exposure to specific chemicals, one may be able then to take responsibility for one's own health care more firmly and more directly.

There is the issue of irresponsible behavior to consider. What is societal responsibility for irresponsible actions? Possessing a gene(s) for susceptibility to lung cancer. Persisting in smoking and developing lung cancer. Whose responsibility? The answers to such questions are not simple nor are they easy.

For the immediate future, advances based on genomic sequencing will be most rapid in diagnostics. And, with diagnostic capability will come greater individual responsibility.

A bit of a scatological example—but technologically, I don't know how else to say it: The Japanese have invented a toilet that allows daily monitoring of blood, sugar, protein, etc., in urine. A daily record can be maintained and transmitted by direct line to the physician. A new kind of patient monitoring, from the home, on-line to the physician's office will be possible.

A further prediction, a credit card-sized record with one's educational record, including Ph.D. thesis, if completed, in its entirety; list of publications; medical record; and genomic sequence, the latter comprising one's identification. Your "thumbprint" will be your DNA sequence, rather than actual thumbprint on file at the police station.

Other interesting developments in medicine and agriculture are occurring. For example, Charles Arntzen at the Boyce Thompson Institute has pioneered a wonderful approach to vaccine delivery by introducing genes for cholera, typhoid, and other bacterial antigens into bananas. Children in the poorest of countries are able to be immunized through their daily diet, without injection, by eating bananas that have the gene that produces the protein that induces the immunoresponse, i.e., a new kind of vaccination. This is very exciting and sustainable technology. The results are promising and field trials are planned.

The U.S. investment in biotechnology, proportionally, has not been equivalent to other countries and appropriate to U.S. capability. I challenge this group to think about this state of affairs.

Let us consider marine biotechnology. The Japanese have invested at least a billion dollars in marine and environmental biotechnology over the past decade. Two major laboratories, costing about $100 million each, with investment by industry as well, have been built by the Japanese. In the United States, at best, we have invested about $100 million annually. Only about 40 percent or 50 percent of this investment is from the Federal Government. The United States is losing leadership in this area of biotechnology which will be—along with environmental biotechnologies—a major component of the predicted $75 billion to $100 billion gross sales for the biotechnology industry in the 21st century.

The Department of Commerce has focused on bioremediation and environmental technology through the Advanced Technology Program. Environmental biotechnology is critical because it will revolutionize industry. We will look to waste streams not to be discharged, buried, or otherwise disposed of, but as added value products. Wastes will be recovered as products through biotechnology. The bioremediation industry is beginning to take off at $300 million or $400 million annually, and moving to the billion dollar range. This is an area of biotechnology that is critical for addressing

environmental problems and in creating new industries.

On the darker side, biological terrorism, exemplified by the Sarin incident in Japan and stockpiling of biological agents by Iraq, will become increasingly a problem. National security in the future will involve deterrence in use of biological agents and/or biologically produced substances. For example, release of the Ebola virus, for which there is no cure, or pneumonic plague, could be catastrophic.

International competition in biotechnology includes Western Europe, where the number of companies is about the same as in the United States. And, the advances are being made at a rapid clip. With the investment being made by the European economic community, in some areas of biotechnology, they will soon overtake us. Japan, Korea, Singapore—Singapore has an extraordinary investment in biotechnology—Thailand, and other countries of Asia, have made significant investments in biotechnology.

It is reported that in China defective fetuses are rejected. The implication is that if a fetus is known to be defective and/or to carry genes for irremediable disease or organically contrary states, it is mandatory that the fetus be rejected. A telling statement that economic grounds for fetal selection has been considered! The inability of society to withstand the enormous economic costs of raising children with serious complements of inborn errors of metabolism may have to be faced in the future.

Biotechnology will change our lives in other ways in the future. Improvement of health, such as the flavor saver tomato is one such example. Would you rather have a tomato with a few bases in a gene removed so that it matures slowly with natural flavor and its natural enzymatic system; or, would you rather have a "golf ball," now in the supermarket, traditionally selected, but so hard it can withstand travel, after which it is sprayed with chemicals to induce ripening quickly. So, would you rather have a chemically sprayed "golf ball" or would you rather have a naturally ripened tomato?

We will have some interesting and difficult choices ahead of us. A very important task is public education in science and technology. The comments this morning about education being critical for our future are important. A nation of Luddites fearing changes taking place in technology will not allow economical and social benefits of biotechnology to be realized.

DR. PRABHAKAR: Thank you, Dr. Colwell. I was going to ask you, Dr. Brodsky, if you wanted to respond on the flavor saver.

DR. BRODSKY: As a company that has invested over a billion dollars in the last decade or so in biotechnology, one of the issues we face is public acceptance. It has nothing to do with the technology itself. And, it actually fits also with some of the comments this morning from Dr. Everhart.

We talk about education K through 12 or improving education for K through 12, so that we will have the people available to do the technology. But, the other side of that coin is having people that are educated enough to accept the technology. If, in fact, we come up with genetically modified plants or hormones to improve milk production or whatever it may be—obviously, we have an interest in all of those—and the public won't accept them, not for scientific reasons, but for lack of scientific education, we have failed. The public is already getting all kinds of mythology thrown at them which they can't evaluate.

I think that's a major problem facing technology in this country.

DR. COLWELL: I agree with you. And, one of the things that we've done in Maryland is invest in a public education center, joined with a modern laboratory. In the Inner Harbor of Baltimore, we've built a 200,000 square foot center. One hundred and sixty thousand square feet of marine biotechnology laboratories and 40,000 square feet dedicated to public education with exhibits designed to explain molecular genetics and biotechnology.

The public exhibits are next to the aquarium which receives about 1.6 million visitors each year.

The public must be comfortable with technology.

Intermingling of science and technology with day-to-day public interaction is critical.

MR. WILLIAMS: I'd just like to ask in your view, Doctor, what are the appropriate mechanisms for dealing with the ethical issues, because I think that's what frightens many of us. How do we really cope with the dramatic changes, cope with the question of dealing with fetuses? When you talk about not being able to afford in this magnificent society to look after children who might be somewhat deformed or something. Those are frightening questions.

DR. COLWELL: They really are.

MR. WILLIAMS: What are the mechanisms for dealing with that as you see it?

DR. COLWELL: Public discussion and public discourse are vital. Had we done this in the 1940's with nuclear power, we might not have run into some of the difficulties that we did. We've tried to avoid such mistakes with position papers prepared at our University of Maryland Center for Public Issues in Biotechnology, which includes ethical, medical, legal, philosophical, and economic, i.e., interdisciplinary analyses of the issues.

On a community basis, with a combination of community, industry, religious, and medical leaders, these discussion can take place. They are very important. Leaving such issues more or less to chance is not a good solution.

DR. BURTLESS: There is one statement that interested me a lot and that was the difficulty that firms have in the United States in attracting investment funds into biotechnology. And, the reason I find that very surprising is that in research that my colleague, Martin Bailey, and I did on how the United States invests in research and development in comparison with the other countries with big scientific establishments, like the United Kingdom, France, Germany, and the Soviet Union, when there was a Soviet Union, what really jumps out at you about the United States is we do spend a lot of money on research and development. The way it's divided between public and private is different than it is in some other societies.

But, the one area in which the United States just has far more investment, it skews its investment much, much more than the other societies do is toward biomedical research. And, I'm surprised that we would be short on biotechnology given that we spent so much on biomedical research relative to the entire rest of the world.

DR. COLWELL: I must agree with you.

MR. DAVID J. BARRAM: I want to come back to the question that Lynn asked you about the ethical

issues and about the kind of dialogue we need to have in this country. It's interesting to live here and to be right in the middle of what is a culture of advocating and spinning with very little evidence-based decision making. It's easy to be cynical about it. Most people are, I think, around here. Who had responsibility to change it? Maybe, if we believe it's critical to the future of our society to change it, as I do, then, how do we change it?

I'm coming more and more to the conclusion that we're going to have to take the institutions that work, which I think are academic institutions and business in this country, and there take the responsibility to change the dialogue.

In the business world, if you don't make decisions based on evidence, you've got a very short life. That is not true in Washington and in the public sector enough. We need to take responsibility for education, responsibility for these incredible ethical issues. If we had the discussion on nuclear power in the 1940's, as you said, we'd be in a different place today. In 2020, we don't want to say the same thing about biotechnology. But, we're not going to get there unless we demand of people that have any cause at all to think they represent us to have this kind of evidence-based civil discussion about things.

I think that responsibility has to fall to people like the people in this room and all of our colleagues, and I don't think we do a very good job of demanding it.

DR. EVERHART: First of all, I'd like to thank Dr. Colwell for a terrific presentation. It raises three issues with me. I'd like perhaps for her to comment on one or two of them. First is, how do we deal with the ethical issues which Mr. Williams raised. This is a very difficult issue. Several years ago, I persuaded Lee Hood and Dan Kevolas—Lee, professor of biotechnology at Cal Tech at the time and Dan, a humanist who is a scientific historian by background interested in public policy—to convene over the course of the year a seminar on exactly this topic, with the best people from around the country. Coming from that is a book called The Code of Codes, which I think is the best book that I know of on this subject. Dr. Colwell may know better ones and may be able to suggest them to you. But, it is at least a start. And, I commend it to you.

The second issue is, in educating the public, I think if you can entertain the public, you can probably educate them. I'm very glad to hear about your building in Maryland. I believe that the AAAS is building a new building in Washington. And, I understand there is exhibit space in that.

But, I think it will be very important to have every visitor to Washington learn that there is something called science that will impact their future life. Their government better be doing something to make sure it impacts their future life in a good way.

And, the third issue I'd raise is a public policy issue. In my initial remarks, I talked about change and the rapidity of change. And, it is changing nowhere as fast as in biotechnology today. And, the institutions we have to deal with the products of that biotechnology were set up 30, 40, and 50 years ago in very different times. And, if there is a place that needs re-engineering, it is certainly in the regulatory mechanisms. The reason one can't get venture capital is because it takes too long to bring a drug to market. And, why is that? A whole series of regulations and tests.

I would think that there could be some new mechanisms, experimental mechanisms that the Federal Government could try, for instance, licensing a company if people volunteer to be tested with this drug, to allow them to do that. They give up their rights of suing the company if it doesn't work and all of that sort of thing. But, we have to develop new mechanisms to compete in the world and the Federal

Government is probably almost the farthest behind in that. And, we all have a responsibility for that, just as we all have a responsibility for K-12 education.

DR. BOTTOMS: I'd just like to respond to Dr. Burtless' comment or question. And, I think it relates back to something that Dr. Colwell said. It's not just biotechnology. We have had a problem in the last 20 years or so in investing and supporting the investment requirement for technology-based businesses that require a long time to mature. It's because of a variety of things which includes tax policy and accounting policies that mitigate against the long-term investment. And, we generate more R&D and more work product from development, from research, than anyone else does. We have a smaller percentage of our development commercialized initially in the United States for exactly that reason. People have talked about it a number of times, but it's nowhere more evident than it is in biotechnology. A company gets started based on a new idea. There was a window of time when the public market would capitalize that new idea, when they'd run through the money that the public market gave them to capitalize the new idea.

The United States doesn't have the same kind of financing mechanism that the Swiss biotech companies and pharmaceutical companies have, or Japan tobacco, for that matter, which has been one of the largest single investors in U.S. biotech companies. It's an issue that can be addressed if people believe it's an important issue. But, it can only be addressed effectively, I think, by mitigating the problem of the total short-term focus, which is not the subject of this meeting.

DR. COLWELL: I'd like to comment further on that. Venture capital is a misnomer. There isn't much venturesome about venture capital. If you've tried to raise venture capital, maximum return on investment guaranteed within 2 years is expected. I'm exaggerating a bit, but the point is it's very difficult to obtain funds for a capital-intensive industry. And, more than that, it's unfortunate that companies increasingly are established with the intent of them being taken over and/or merged, rather than with the intent of growing to mid-size or large companies.

It's also important to emphasize that compared to the computer software and chip industries, biotechnology has managed, within 15 years, to reach gross sales of $5 billion to $10 billion, despite being heavily regulated. The other industries are unregulated.

DR. BOTTOMS: If I could just respond briefly, since I am one of those venture capitalists that you talk about. Our job is to avoid risk. If you look at the statistics, you'll find out that the companies who are successful in finding financing from professional sources have a much higher success rate than companies founded by any other mechanism. Therefore, I think there is evidence that there is some success there.

But, industry as it's structured has no mechanism to capitalize things that take as long and cost as much as a new technology for producing integrated circuits or technology for producing biocircuits.

DR. COLWELL: That's true.

DR. BOTTOMS: And, we need to have a different mechanism. I think it's tax policy and accounting policy and things that move us away from short-term focus. There is no other way to do it that I know of.

DR. PRABHAKAR: I think the topic of short-term versus long-term focus is a very appropriate one. We can pursue that at greater length.

MR. COATES: I'd recommend that you abjure all discussion of any significant corporate or government issue in ethical terms. Ethical discussions are essentially self-defying and paralytic for the following reasons.

Ethics has become a voguish category in government and the corporation, and it's a voguish category that is the receptacle for a whole set of interesting new issues that those organizations are confronted with. Not having a proper place to fit them into the organizational hierarchy, they get thrown into this ethical box. And, most of them are simply not ethical.

But, the more important reasons for not talking about ethical concerns is that it ends up being, "my old man can lick your old man" kind of argument. I'm sure that not more than two people in this room have ever spent more than a year in serious studies of ethics. Yet, what makes us think that we're qualified to talk and analyze in ethical terms? It's as if because I've been sick with pneumonia, I have the right to talk about medicine. Or, because I've been infected with a fungus, I have a right to talk about plant biology.

So, essentially, we're unqualified for that discussion. But, more significantly, what the ethical discussion does is it invites strong-willed ideological people to come in and dominate the discussion. Look at the current situation with right to life or freedom of choice. The ideologues have occupied the full ground and rational people no longer have any contribution to make to that discussion.

So, I recommend you abjure this. Instead, I think that what one should do is look at whatever the issue is that you think is ethical, that you already dropped in that hopper. And say, let's look at what it means to our planning. What does it mean to our reputation? What does it mean to our production? What does it mean to our market? What does it mean to our work force? Look at it from every other conceivable point of view that you're qualified to deal with and then see if there is anything left that would fall into an ethical hopper.

But ethics is essentially either self-defying or paralytic, albeit voguish.

MR. MITCHELL: I'm a little bit surprised that the discussion about biotechnology is so dismal. It strikes me as one of our really great successes as compared with most other industries. I mean, we have three quarters of the world's gene patents, and we've invented 80 percent of the drugs, and so forth. And, it does seem to be an area where the United States genuinely doesn't have any major competitors as yet in a way we have in most of our other leading industries. And, I know that people are obviously coming here because this is where it's done and this is where the climate is better.

So, what is the issue? What's the thing we want to face?

DR. COLWELL: The issue is, complacency. We have much more fierce competition than recognized. I've just returned from Japan, having reviewed their exploratory research program. The investment being made there is intensive and highly focused. In the United States, the attitude prevails that we're ahead, doing okay, and have a tremendous research capability. However, in terms of marketing products, we are not competitive.

DR. PRABHAKAR: I had started joking that the stages in the evolution of the technology are discovery, hype and investment, over-hype and over-investment, disappointment, under-investment, and then finally success. And, it is possible that biotechnology is going through some of those curves and dips.

DR. GREGORY TASSEY: I wanted to follow up on what Mr. Mitchell said. I think the venture capital market in the United States gets a bum rap, as this discussion implies. I talked to a lot of economists in European countries, Japan, and elsewhere. And, our venture capital market is the envy of the world. It has some problems. It has a very cyclical nature to it, which is what has happened in particular to biotech. But, by and large, the amount of capital, risk capital that's made available is way ahead of our competitors.

The second point is you cite the Japanese investment, the German investment. Certainly, when they see a winner, it's natural for them to try to get on the bandwagon. And, that's what's happening. But, we're certainly not slacking off as shown by the budget of NIH. The amount of venture capital currently being made available to biotech firms, to my way of thinking, is substantial.

MR. JACQUES GANSLER: I just wanted to make a quick comment. It's been bothering me that every meeting I go to of this sort always says what we have is this very short-term focus on return, and then go onto the next topic. And, yet there always are these recommendations, you know, for different forms of change in public policy that could, in fact, change that orientation and would be very positive not only for biotech, but also for most technology investments. And, yet, we never seem to get beyond recommendations in these discussions. I just wanted to raise it as a topic.

DR. PRABHAKAR: Dr. MacArthur, I want to tie some of this conversation back to your comments. It seems to me that you were describing the enormous pressure and restructuring in the health-care system in this country that is driven by rapid growth in escalation of costs, which, I think, to some substantial degree, is driven by new technology itself.

Given where we are in restructuring health care and given those pressures, how do you see the role of these kinds of new technologies and what kinds of additional forces and pressures do you see coming from them?

DR. MacARTHUR: Traditionally, academic health centers have trained health-care professionals and have provided clinical settings where new drugs and therapeutic inventions can be evaluated, improved, and expanded. Training and clinical research are expensive, but, in the long run, the "bench to bedside" approach is cost-effective. The clinical research approach is akin to the introduction of any new technology, the cost of which can be brought down by continual improvement. In an academic health-care setting, the benefits of interdisciplinary science and technology are also realized. For instance, I recently toured the teaching hospital of the University of Maryland at Baltimore, which collaborates with the various biomedical and engineering departments of the University of Maryland System. Together, they are looking for noninvasive imaging techniques to detect changes in the brain that might help diagnose, say, schizophrenia—a brain disease that has cost Americans billions of dollars.

Rita Colwell has given us a marvelous vision of the future of biotechnology. I believe that—left to managed care as we know it—there is no future for the therapies she described. Unless managed-care organizations shoulder their share of the expenses for development and improvement of those therapies, academic health centers will be unable to carry the burden alone. This turn of events could put the emerging biotechnology industry out of business. We will see.

The infrastructure of the academic health centers is needed as the next step in the development of therapies and their improvement. But, now that more and more of our health-care dollars are going to managed-care organizations, academic health centers are in serious financial straits. They are losing

revenues from privately insured patients, and, if public policy is changed so that they lose Medicare patients as well, many may close their doors. So far, most managed-care organizations do not do training or clinical research. They have counted on using the trained professionals and the improved therapies provided by academic health centers; they are "takers." If the academic-health-center well dries up, the real losers will be the American people, who expect the best medicine in the world.

I want to point out that, at a time when big government is being blamed for waste and for overregulating industry, if managed care draws most of our health-care dollars away from academic health centers and takes but does not give back to our knowledge base, this bankrupt state of affairs will have been created by the marketplace. What irony!

DR. PRABHAKAR: So there is no dearth of monsters being created.

DR. MacARTHUR: Well, that may change when the movement to managed-care providers shakes down and there is no more free lunch for them. Managed-care providers may then invest some of their assets and undertake clinical research and training themselves. But they see no need to get involved now, and only a very few are conducting research. Hopefully, they will respond to pressure from their subscribers for quality. And, as in other industries that serve the public, Federal and state government may have to step in and/or help them to recognize the advantage, to ultimate cost savings, of clinical research and development and continual improvement.

**Technology and Government Policy: What Level is Appropriate?**

MR. GALVIN: Thank you, Dr. Prabhakar, and ladies and gentlemen. I sent down to the staff a single page sheet of paper, which I will now invite them to pass out to the group as I will refer to this single sheet momentarily [see end of this section]. What I would appreciate would be your courtesy of setting it aside and permitting me to lead you through it very briefly at the appropriate time in my comments.

The question that is laid alongside of my name is: Is there a role for a partnership between the federal and the private sector? And mostly my answer to that question is yes. And the answer derives from the Constitution. And let me remind you of something that I find that not everyone has recalled. The Constitution says in Article I, Section 8, that the Congress shall have the power to promote progress in science and the useful arts. Let me repeat myself, because this sentence goes on and it has a particularity to it.

The Congress shall have the power to promote progress in science and the useful arts by reserving for a limited time the exclusive right to authors and inventors, that of their writings and their discoveries. And, of course, the result of that is that we now have a patent and copyright office.

I respectfully suggest that the founding fathers had a much more profound intent behind that, although they could not possibly have imagined what useful arts would represent or what science might generate. This is because what they essentially needed to do was to create the means of having an affordable large republic, which was the only means that they thought of that could preserve freedom for the rest of the long existence of this country.

I will leave you with that, but I think it's quite significant that I put one point of emphasis. That's the only right granted in the Constitution. It's the only place in the Constitution where the word "right" is written. You might say the Bill of Rights. The Bill of Rights grants no rights.

Madison, recognizing that we didn't need a Bill of Rights, but being obliged politically to at least compose them, composed them in a very clever way by saying, Congress shall pass no laws, and then the rest of the document, which I paraphrase, goes on to say, Congress shall pass no laws abridging your right to freedom of assembly, speech, et cetera, which rights you had long before we ever imagined we'd have a Constitutional Convention. They are the natural rights of man.

Well, our founding fathers in effect said, Congress shall have the power to promote progress in science and the useful arts. And I hope we can succeed in doing that. I therefore am mostly positive, but I'm going to leave with you eventually a question as to whether or not both parties are going to be able to live up to whatever we might refine—I don't know whether we can define a thing called partnerships. I'm not going to spend much time talking on the head of a pin, but partners are normally joint principals, p-a-l-s, and the Federal Government and the private sector—and incidentally, I am now including all universities, whether they're state universities or not, as the private sector. Forgive me for being simplistic.

But we really aren't joint principals. In one sense, the government is the 400-pound gorilla. In another sense, it won't be long before the private sector will be far more significant in terms of size and influence, and I'm going to portray that for you in my expression of biases that I'm going to share with you in this short comment.

Well, I don't know that partnership is the right word, but it's a neat word. It says, why don't we cooperate with each other, link, have an alliance, et cetera, et cetera. And we ought to strive to

accomplish what the Constitution at least partially directs us to do and we ought to certainly work together just as effectively and harmoniously as we can.

Well, let me now just profile some companies. And my guess is these are slightly exceptional, but I hope they would provoke your interest. I think there are some very significant things happening with regard to what the private sector's profile is going to be here in the course of the next score of years. I'll personalize it, meaning I'll particularize it to our company, but I don't think we're so different than other people.

Motorola intends, because it's the natural expectation, that in the lifetime of my son, who is now a third generation head of the corporation, that 95 percent of our business will be outside of the United States. That's not forsaking the United States. That is expecting a very robust American economy and Motorola's immense success inside the United States.

The algorithm is quite simply an algorithm of population. It's not gross national product. The only way we look at economies basically is population. And we think we're showing the way in telecommunications. And we can do so in energy. And we can do it in a couple of other things, to where the rest of the world is going to move up or could move up an awful lot faster. And, therefore, we must think not of the United States being the center of the world. We're a 5 percent factor. The government will be a 5 percent factor. Sure, it will have an extra division or two to handle some very noble causes, like we try to do in Bosnia. But economics wise, we've got to think in terms of the fact that the United States is a 5 percent factor in the world.

Companies like ours are going to grow, we think, at 15 percent a year. So we'll grow from 25 billion this year to 50 billion by the end of the decade. That's 15 percent compounded, and by five times you double. Then it goes to 100. And then it goes to 200. When we have to grow from 200 billion to 400 billion in 5 years, that's only 15 percent. Somebody says, you can't do that. Well, how come we did it up to now?

Lots of people are going to figure out ways of doing this and have strategies to accomplish them. When that happens—and I like to use decimals—when Motorola finally becomes a trillion dollar corporation and we spend 10 percent of our sales on engineering, we'll have a $100 billion engineering budget. That's three times the size of the Federal budget for real engineering, not testing and all of that kind of stuff.

Why not Hewlett-Packard? Why not Monsanto? Why not somebody else? So you say, Bob, you're never going to get there. You may get $500 billion by that time. Well, okay, so I rate it down.

The point is, the private sector is going to be over there a heck of a lot and doing a gigantic amount of engineering on its own. And at this point in time, I had lunch with the gentleman that manages this for us or he facilitates it. We're setting up research labs. He just came back from Paris, Russia, China, Malaysia, Singapore, Germany, Switzerland. So our research is now being spread all over the world, because that's where there are also some very bright people. I happened to sit at lunch with this same gentleman and a man who had been an associate director at one of our largest labs. The scientists in the room would know him.

He's a distinguished fellow and he's now consulting with us to try to help us better interrelate if we can with government laboratories. And my associate, who is a very stable, quiet, Asiatic gentleman, was asked by this former government or laboratory associate director, well, how do you rate on a scale of 1 to 10 the ability to do business with government laboratories. And he said, oh, I'd give it about a 3.

At which point, I said, Terry, what's your answer if he had asked the question in terms of getting along in the Ukraine. He said, that's an 11.

Now, if the Federal Government were to consider itself an entity that had to compete and that knew what these kinds of things were—and my guess is Dr. Good could give this speech better than I could, or Dr. Prabhakar or many others—and then had the chance to believe it, then I say that there is a question as to whether or not the Federal Government in the term that I'm speaking of, the next 5, 10, or 15 years, is going to be able to measure up to be worthy to be a so-called partner. You've got the money. So if you'll pony up, I guess we'd accept you. But we're not counting on you. People like ourselves, we're not counting on you.

Now, if I can, I'd like to just conclude my comments by asking you to look at the sheet of paper that I passed out or look at it again if you would. And let me walk you through it very briefly. I dare to start this at least with the same phrasings of the Constitution, but it's not intended to be a Constitutional amendment. It's just a rhetorical device.

And I say here that Congress shall have the power to promote progress in science and technology, including science and technology applied world wide commercially. There's a very challenging issue in that short thing. Let's cut out this stuff about if the money is spent in the United States, it can only be used in the United States. Our customers are 19 times more overseas. We're not going to run any strategy based on some requirement that we have to restrain our use of technology because a dollar was spent here, the taxpayers' money, only in the United States. To heck with it. We've got to go and serve the other 19.

Funding multi-year research and development in general fields of investigation, I know there is a so-called Congressional problem. But that's your problem. Change it. Rewrite the rules. It's got to be multi-year research and development funding, defined from time to time by qualified science and technology professionals predominantly chosen from the private sectors, which include the universities, whatever the venue of those universities would be. Roadmapped, if possible. That's a particularity of mine. I didn't invent it, but I certainly invented it for our company. And our semiconductor industry, I think, is showing the way as to how roadmaps can be used for very general, very generic and very energizing programs of a very broad nature. And there is a process there that would allow that we would most effectively pursue mostly productive areas.

The Congress will authorize and appropriate funds in block sizes to broaden generic categories of investigation. Stop micro-managing. I don't know any Congressman that has the credentials to allocate funds for science. But I think that collectively, with the wisdom of the kinds of entities around this room, including government institutions, but with a lot of bias in favor of universities and the private sector, you would get very good definition if the partner that happens to have a facility to have a lot of money available would just simply allocate it in block form.

And then through depoliticized institutions—and don't hold me too much to my modest examples. The National Science Board for NSF or the national academies if indeed they could be refocussed, or newly formulated corporatized boards of trustees, which are or will be endorsed and established for these research and engineering government's purposes, give the job to them.

And then whatever our so-called government laboratories—unless it's a warfare center for the Navy or a particular activity of ARPA, there are always going to be very worthy exceptions, but almost all of it, give it to somebody else to run it. You, the government, have a big block of money to give. That's your job. Then get out of the way and let effective people spend it for you.

And the members of the private sector with relevant interest and potential benefits should expect to share in particular funding responsibilities. I think this should become a much more active policy. The private sector should expect to pony up in this area.

I think we're learning how we can do that. It's going to take some culture changes, SEMATECH is one such example. The Electric Power Research Institute is another. There must be five others that I don't understand well enough.

But the private sector has to pony up if some of these other things are to get done.

And, finally, the depoliticized facilitating entities will account to the Congress annually to a new standard of Congressional satisfaction ordained in this legislative policy, which will adopt audit practices and reviews consistent with the standards and methodologies of the private sector financial reviews performed by public accounting firms, and all other methods of auditing and review will be eliminated. In which case, the productivity of science and technology will go up at least double, and then maybe we could afford to be partners.

Thank you.

DR. PRABHAKAR: Thank you, Mr. Galvin. Comments and questions and conversation on this?

DR. EVERHART: I like your proposal very much, Mr. Galvin. I'd just like to ask you a question, which is self-serving as a university educator. But, nowhere in your proclamation here do you put in a requirement to provide for a work force that is educated enough to put this science and technology research into practice for the benefit of society here and abroad. And I know you know that's important and you must think it's implicit. But should it be explicit?

MR. GALVIN: Dr. Everhart, you are right. First off, this is only one page. We could have written a second page, I presume. And your point is—by all its implications, I totally agree with. But I guess you probably talked about that so ably over the morning time, I'll just leave it go at that. Yes, it is implicit. This is a systems problem. And the system implied is education, and it requires ethics, however we define it, et cetera.

All I did was try to find a narrow slice of the issue, wherein there would be enough controversial suggestions that come out of my kind of biases that would under themselves be worthy of chewing on. Incidentally, please don't get off on education too much here. I hope to stay a little bit with this.

But one of the things that I think could help the education thing is we concluded a long time ago that education in our companies doesn't cost any money. That's a fact. So let's go spend a lot more money. But I hope we can stay with this.

DR. PRABHAKAR: Then we'll come back.

MR. GALVIN: Well, I hope after I leave, you might get back on that one.

MR. SALDICH: I just wanted to piggy-back a little bit on Mr. Galvin's comments. Dr. Hermann started this morning with kind of a glowing description of where this country stands, which was, by the way, largely ignored by all subsequent speakers. The facts are that the country is in pretty good shape right now by most measures. It's certainly not without problems, but basically in pretty good shape.

What comes to mind from Mr. Galvin's comments to me is one of the dilemmas of being the CEO of an international company—my company right now does about 70 percent of its business outside of the United States and has about 60 percent of its employees outside of the United States. So the employees of my company are our employees, whether they're Chinese or Brazilian or French. And we think of them as our employees, not as our foreign employees. In fact, we stopped describing our company as an American company. We describe ourselves now at the suggestion of our employees, by the way, as an international company which happens to be headquartered in California.

This puts you in kind of an odd position from time to time, because you are inevitably doing things which are good for your company, which in the opinions of many people and in fact maybe in fact are not good for your country. You're in an odd position, at least many people would assert that they're not good for your country. So the dilemma, it does exist.

I think the real irony that comes to mind with Bob Galvin's 95 percent number is this. That in a curious way, it's the businessmen of the world who are becoming the real one-worlders, when you think about it. The least likely crowd to assume that mantel are the business leaders of the world, because we are operating in a boundary-less way. We're really not thinking too much about the boundaries we cross with our people or with our products or with our technologies. We're simply trying to do what's best to build and preserve our companies. And that really is the end game that we're in here. How do we build a successful company?

So I just sort of offer that for you to ponder. Our objectives are to obsolete our own products, to generate growth through technology, to drive for better companies. Motorola has taught us a lot about how to do that, how to become more effective companies. To develop our own people. The thought that we are indifferent to our own people and their development is at a minimum offensive. And it's inaccurate.

Our people are our resource. As corny as that sounds, it is true. And the only way we can succeed is if our people develop and if we invest in them. Our people are golden to us. And do we sometimes have to lay some of them off? Yes, we do. And that's very, very painful. And anyone who thinks it isn't hasn't done it, I would submit.

But we are in a very fiercely competitive world. We are doing our best to build great companies. And I think America should be proud of what it has in its industrial base right now. But we are internationalists, more so than many of the folks who have been urging internationalism on us for a long time.

DR. GANSLER: I wanted to ask Mr. Galvin two questions that relate to this paper, which I happen to think is great. Particularly the idea of the block grants from Congress, which make so much sense. I was surprised to see that, especially after the comment that ARPA seems to do a good job, that the normal funding institutions, NIH or NIST or the Department of Transportation or the Department of Energy and so forth, are bypassed sort of with the recommendation going directly to, say, the National Academy or places like that. That struck me as sort of decoupling the mission agencies from the R&D needs that they might have and that they might fund for high risk, long-term investments. That was one question.

And the second one had to do with if you go back to the Constitutional objective to promote progress in science and technology, my perception is that the amount of funding that the government would do is probably the secondary consideration. And that there would be many other techniques, whether it be taxes or other things that could be used to encourage the promotion of progress in science and

technology. And you seemed to focus on the funding itself directly. I was curious as to whether you felt that was in fact the best way for the government to get involved.

MR. GALVIN: Your perceptive observations and/or questions are a high testimony to the assembly of this wise group and I compliment you. Again, this is a one page document. First off, there would absolutely be exceptions to something as general as what I have said. Let's take a warfare center of the Navy. We'll need warfare centers of the Navy, so there is going to have to be something in the DOD budget for that kind of thing.

Whatever happens to the aggregation of something called commerce—frankly, I hope it stays. But there would have to be a budget for the standard setting. And I'm being pedantic in that detail. So there would have to be exceptions.

Concerning the second point, this is meant to be in effect the tactical aspect of this part of the budgeting process that would have an impact on improving science and technology, sort of the operative part. But indeed all of the things that you have otherwise talked about that would encourage better education, would encourage better investment policies, et cetera, those are even more significant.

But I was getting down to when a Congressional committee is thinking of appropriating $600 million for some science program, if they're going to do that, please do it more this way. May I just ride side saddle on the fine observations that Mr. Saldich made about the fact that, like it or not, we're all international. And we better like it, because it's absolutely the best thing for our country.

And I would remind you that when we try to be wise—and it's pretty arrogant to think that anybody is particularly wise to me one of the ways of searching for wisdom is to appreciate the merit of counter-intuitiveness. And the intuitive is to, say well, it's America, focus everything here, only investments here, et cetera. And absolutely the opposite is the right way to go. The counter-intuitive is almost always the right way to go if you're going to make progress.

So, for example, investments are the algorithm of exports. The more you invest overseas, the greater the export you create, because, among other things, your present products follow what you have invested in. And how are we going to have a great international market if we don't create the market overseas? I said to Minister Nuwait, a wonderful lady who came and visited us for two months on a sabbatical, why do you think we're interested in investing in your country (China).

And she said, oh, very simple. You want our large market and our low cost labor.

And I said, well, my answer will probably surprise you. I said, absolutely, we're interested in your large market. But we're not the slightest bit interested in your low cost labor.

How can you be a large market if you're low cost labor?

We have to build industries. We have to build markets. And there are a few of us that think this way. So we go out and change the rules, make investments, create customers who have discretionary income. And then they can maybe buy Proctor and Gamble's toothbrush, but they'll finally have to have a two-way radio or a pager to go along with it. And there is an opportunity for the energy industry to come along and create more energy and then they'll spend more, et cetera.

So our job is creating an economic viability overseas. And, frankly, to some of us, that's paramount in what we do. And that's why we can grow our companies. We grow the environment in which we

grow our companies.

DR. PRABHAKAR: I'd like to use my position to interrupt this conversation because I really want to probe this for a moment. And then I'll come back around to some of the hands that were raised. A question for both Mr. Galvin and Mr. Saldich. I think you characterized actually quite eloquently what companies focus on, how they think about their economic futures and economic growth.

My question to you is, how does that relate to national goals? How does that connect to issues for citizens in a nation like this?

MR. SALDICH: Well, I think Mr. Galvin said it perfectly just now. That we are in a world wide society. We're major players in it. We're going to benefit from the growing wealth of the world. Bob Hermann said that America today represents 5 percent of the world's population and 20 percent of the world's economic activity, moving towards 10 percent. Which means that success for us will be halving—cutting in half, our share of world's economic activity.

One thing we've all learned in alliances is that the key ingredient to be a successful alliance partner is to make your partner a success. And that's what's happening world wide. I think if they're successful—this is what I think Bob Galvin is saying—we become successful.

MR. GALVIN: I am very pro that there should be national goals. And I don't care what the rhetoric is, national planning or what have you, if the profile of the peoples and energies that are engaged in it are biased in the direction of the private sector defining what it is -- and, again, the private sector is everything other than the Federal Government with this simplistic definition.

For example, I am an advocate that it ought to be the national goal of this country to cause that those who have the means and the talents, should for the next 10 years to 20 years be out establishing energy generating plants in every quarter of the world that they could possibly imagine there might be some compensatory benefit to that energy investment, as soon as possible.

We have all manner of utility companies right now that are living in fear—somebody was speaking of the fear factor—because now they're going to be deregulated. If every one of those companies would pick a country and decide they were going to be a dominant force of providing energy for that country that needs energy, energy makes people productive. Productive people earn more money. The more money they have, the more discretionary income they have, the more the economy is made dynamic, et cetera.

So, yes, there should be national policies. But it shouldn't be governed by the government. So we have to have a new culture or a modified culture that in effect says, let's aggregately accomplish things. And I believe the culture is now installable or inspirable for collaborative action on the part of competitors in industry that can cause that to happen. Again, I think the semiconductor industry is a wonderful example of that.

So, yes, particular national policies ought to be established and they ought to be driven and helped and facilitated by the federal government with a strong bias from the private sector.

DR. HERMANN: I wanted to return to the dilemma that Mr. Saldich put forth, because I think many of us who are American based and international in scope have to deal with this problem both intellectually and publicly. And I would like to argue that we can split the response of dealing with this

dilemma into two pieces. This is at least a version of how to do that. And one is to say there is no question, but we are chartered and legally obliged to respond to our owners to do good in a global economy. And we will be driven to be self-centered with respect to the objectives of the corporation or the company.

But separately we are, I believe, a citizen. And in this country, we are a corporation citizen. And we have citizenship responsibilities which are different than the responsibilities brought forth in the fiduciary responsibilities.

So I believe that as corporations and as leaders in corporations and companies and private sector institutions, we have the obligation to make our confidence, our judgment and allegiance to the community within which we operate as fine as it can be. And I believe that we have a very keen selfish interest in being located in a solid country with a solid economy, a strong position in the world, and that our position in this international domain is strengthened by operating out of a fine country. We have an obligation to make that occur. And I see it possible to deal with both of those without conflict.

DR. BRODSKY: We have another self-serving reason for raising the standard of living of people around the world. And that has to do with not only creating our own markets, but also in controlling population. Probably the greatest threat to our future and the sustainability of the earth is out-of-control, population growth around the world.

And the one factor that seems to relate to population growth consistently is standard of living. The higher the standard of living, the lower the population growth. So, in fact, if we can spread technology around the world that helps raise standard of living, get crops into Africa that are resistent to blight, so that people don't have to have large families to survive, et cetera, I think we stabilize the earth in addition to creating affluence there in terms of markets. In terms of our long term survivability, I think it's an imperative.

MR. GODFREY: It seems like this focus is on the creation of technology which sometimes gets interpreted as a creation of products. So how are we going to emphasize the adoption of technology and the risk associated with adopting the manufacturing changes? I think that's a problem.

MR. WILLIAMS: First of all, I just wanted somewhat impertinently to make Mr. Saldich's day by assuring him that there are a number of us who have been accusing companies like his of being international companies for some time and not really being American corporations. So we find common ground in this affirmation.

(LAUGHTER)

I am really thrilled at the idea that we're going to move around the world with all of our international corporations and create higher living standards and consumers and purchasing power, and that clearly is obviously in the most commonsensical of terms the direction we need to go.

I have a little difficulty in terms of my experience in these issues—present company probably excepted, I'm not really sure. I know that I shared many trade battles with Bob in a very positive atmosphere. So I'm not making an accusation about Motorola in this regard. But in general terms, the international business community, the American international business community, if you will, has not in my view been very sympathetic about the labor movement's attempts to establish international labor standards, international standards of human rights, banning of child labor, and international environmental

standards. We had an enormous struggle about NAFTA.

And the heart of that from the labor movement's perspective was precisely from our point of view what we're talking about, which was try to have international trade agreements that would have some guarantees in them, that as the economy of the developing country or the newly industrialized country or whatever the circumstances might be, that as those economies developed, indeed the benefits of that economic development would be shared with their workers and with their people generally.

And we had from a labor movement perspective two points of view on that, two particularly important issues. One, obviously to guarantee the competition in terms of wages and benefits and so on would be on as level a playing field as is conceivable in a developing international economy; that we would push things in that direction.

And, two, and I think even more importantly, that we would be creating customers around the world, so we would not have exploitative trade agreements that permitted corporations to simply go and take advantage of low wages. But we would be creating countries where there would be the potential for real trading partners with real purchasing power. When the Koreans built Pohang Works and had this marvelous steel company in South Korea, the most advanced in the world, for a long time, they simply poured steel products into the international marketplace without any compensating improvement in the living standards of their workers.

So you would go to visit Pohang Works in South Korea and the parking lot wasn't full of automobiles, it was full of bicycles. Now that's changed. The Korean workers have gotten a little freedom, gotten a little democracy, gotten some chance to organize, some chance to improve their wages. And now when you go to visit Pohang Works, you see a parking lot that has automobiles in it. We've developed some customers in South Korea.

But it seems to me that if this vision that we've just been hearing from both Dr. Hermann and Mr. Saldich, which obviously is a pretty exciting vision, if this is to have real meaning, then the international business community needs to ally itself with the labor movement and other progressive forces in the pursuit of decent living standards and guaranteed improvement in living standards, wages, benefits, the environment, and all of the rest in these countries as their economies grow.

MR. GALVIN: I'd like to ally myself with Lynn. He and I have shared many discussions and we've found so many more times than others that we were very congruent with each other. I am totally in congruence with your fundamental. Let me give you an anecdote. The preamble to the anecdote is that whereas we talked a lot about education this morning, one of the things we have to do is, among us "leaders," we must continue to educate ourselves. We must benchmark ourselves. We must learn from each other. And we learn from so many of you. And once in a while, companies learn from us. So we must be role models. And let me give you now a situation.

In 1986, I said to Jiang Zemin who is now the Chairman and to certain others of the vice chairmen of China when I visited there, if you let us come in and own our own business on a capitalist basis, we'll be your role model. In January of this year, Jiang Zemin personally went to Tienjan. He spent the better part of a day, or roughly 5 hours, going through our factories and all of the things we're doing for our Chinese employees and the way we're running our business.

He was so impressed he went back to Beijing. And he said, next week, I want all of the members of—whatever they call it, the politburo—to go to Tienjan, see what Motorola is doing with people, how they're being paid, how they're being treated, how they're living, how they're being made into better

people. This is how we want employees to be treated from a labor relations standpoint. I don't know that we can call this "human rights." I don't think we've reflected back to their prison system, yet.

But to the degree that we can have an influence in places, I respectfully suggest that we can do just exactly what we want. It's going to take a little time, however, because some of us take a long time to learn these things. We business folks are just kind of as slow as anybody else. But once we learn something, we get to be pretty good at it. And I again look at the analogy of quality. I think that the government wisely established the Baldrige standards.

In the last 10 years, there's been quite an elevation and we're all a lot better on quality than we were before. I think we can be an awfully lot better on labor policies around the world in the next 10 years, because nobody can compete with us—well, China is so big, at least by some indexing of comparisons, but they can't compete with us in China unless they start treating people well too. So we sort of bring each other up.

So I think inside of this little single sheet of paper that I have here, which hopes that we can have enough science to make better products that will be better manufactured and financed, and that we are able to run, I think we can have a very positive impact on elevating standards of labor relations and compensation.

MR. COATES: Looking at Mr. Galvin's business forecast, the trillion dollar corporation, if one took that seriously, one would also have to believe that there will be other trillion dollar corporations. So let's assume that there are 10 or 20 of them that are involved in the same time frame. And if they followed your prescription, 10 percent of revenue for research or even R&D, you're talking about a situation that would just simply swamp out anything that government is doing or has done.

That makes this one page utterly irrelevant, because the new gorilla in the R&D game is going to be corporate research. So the most I would see this would have any value for is as a transition piece.

But what's left out of this may in fact be the interesting opportunities for government. Namely, you give no discussion of those areas in which there is market failure. And government may be the ultimate place for market failure. Who is doing research really? What's the business interest on restoring soil? Where is the research going on earthquake prevention? What are the real dollars going into research for the handicapped and the impaired?

So all of those places where there is market failure is essentially the residual opportunity for government, if one takes seriously your claim for the future.

But the more important point I would like to make is suppose we did follow your prescription for helping development in these developing countries, suppose that we did build the power plant a week that China will require to maintain its 8 percent growth.

If we look at the time cycle that is in your mind, I presume, 15 years, 20 years, something of that order is what we're talking about, what will happen in international commerce in that 15-year period? Every time we invest in the Chinese or the Malaysians or the Indonesians or the Philippines or the Indians, they're not going to allocate a portion of their population to live as if they're in New York or Scarsdale. What they're going to do is continue to have relatively depressed wages in order to move effectively into the international market competitively.

So the strategy you're outlining in this very important 15-year transition period is going to be an

international disaster for the United States The price elasticity of labor demand is so steep that however much the Chinese are jacked up, double, triple, quadruple their wage rates in that 15-year period, they're still going to be able to drive down the cost of products and kill us in international trade.

So I think that your argument is fundamentally non-systemic or even specious. I think you have to look at the argument systemically over the period that you're talking about and look at what each of the actors would in fact be likely to be doing. And I think it just guts your argument.

MR. GALVIN: Sir, that is a very intellectual statement and it is as specious as any I've ever heard. So we might as well look each other right in the eye. Sir, these people are not going to depend for their competitiveness on low cost labor over the course of the next 15 years to 20 years. As a matter of fact, what I'd really like to do is to cast this in a 50-year cycle, because nothing happens as quickly as 10 years or 15 years as all of us would recognize.

The competitiveness of our people in Tienjan is a function of the degree to which we have applied to them the highest order capital that we can apply to any place in the world. And we can produce—now I'm going to switch gears for a minute—we can produce in Arlington Heights, Illinois or Boca Raton, Florida as low cost as we can produce in Tienjan. And we can't produce low enough cost in Tienjan if we don't use exactly the same capital and science based businesses. And that's going to be true of more and more and more businesses along the line.

So the world of 2025, the world of 2050, that's only 30 years away, is going to depend on the employment of capital, on tools, both of which I think have been alluded to in prior discussions, on educated people to do the job. And so I think there is a high systems relevance in what I have suggested.

But I respectfully suggest that neither one of us know how to orchestrate this situation. And what I've learned from my experience is that if one gets a general idea of where one wants to go 30 years from now, first off, we know that whatever we exactly think of will be wrong. But if we start going in the right direction, we'll muddle around and figure out better words than I wrote 5 years from now and better words 10 years from now. And we'll gradually shake it into the right kind of thing.

I just think there are more ponies in what I've suggested than doing what we were doing yesterday.

Conference Handout:

## Mr. Galvin's Model for Government-Industry Partnership

The Congress shall have the power to promote progress in science and technology including science and technology

- applied worldwide commercially by
- funding multi-year research and development in general fields of investigation as
- defined from time to time by qualified science and technology professionals predominately chosen from the private sector.
- Roadmapped, as possible.
- The Congress will authorize and appropriate funds in bloc sizes to broad and generic categories of investigation
- through depoliticized institutions such as the National Science Board, National Academies and newly formulated Corporatized Boards of Trustees which are or will be endorsed and established for these research and engineering governance purposes.
- Members of the private sector with relevant interests and potential benefits should expect to share in particular funding responsibilities in part.
- The depoliticized facilitating entities will account to the Congress annually to a new standard of Congressional satisfaction ordained in this legislated policy which will adopt and audit practices and reviews consistent with standards and methodologies of private sector financial reviews performed by public accounting firms.

## Concluding Discussion

DR. PRABHAKAR: Let me give everyone around the table a chance to revisit previous topics from earlier in the day. If there are brilliant insights to be offered, here is your opportunity.

DR. BRODSKY: We still operate basically a linear life plan. You get educated at the beginning of your life, you work in the middle of your life and you have retirement at the end of your life. I have children that are now out of college, who aren't operating under that paradigm at all. They went to college. They retired. They go back to college. They work. They retire.

And in fact we are seeing more and more a different paradigm among young people that education is going to be a cyclical thing. It's not just remedial that we need to train a few people here and there during their lives.

But in fact, you won't get a plug of education at the beginning that has to carry you through your work years. That's going to change a lot of the ways that we think about education and work and play and how people go through their careers.

We need to think about how people will use technology in terms of their different life stages—play, work, education.

MR. BARRAM: I want to ask a question of Dr. Colwell. As you were talking, I was imagining a dramatically increasing life span and perhaps a dramatically increasing vital lifetime. If you took the claims of Melatone we are all going to be pretty vital at age 210. It sounded like progress in biotechnology could have some of that same kind of effect.

Do you think that is something that is likely to occur in the next 20 years or 30 years.

DR. COLWELL: Do you mean the extension of life span?

MR. BARRAM: Yes.

DR. COLWELL: When social security started, the life expectancy of men was 59 years old and the retirement age was 65. Today, the life expectancy is 77 and the retirement age is 65. That's one of the issues that faces us.

MR. BARRAM: But what if our life expectancy changed dramatically; and might it change dramatically?

DR. COLWELL: Right now we do have people who live to be 115 and 120 years old. So it means that we haven't reached the end of capacity of the life span. We are simply living in the environment with all of its interactive factors. The average tends to be shifting towards the longer life stage.

Yes, knowing that you have certain genetic disposition and being able then to live your life strategically, you then create the odds that gives you a longer life.

The other question that I was asked similar to this was what does that do to the population. Aren't we going to end up with standing room only?

The interesting thing is that with an improved standard of living you get smaller families. But I would

add that the really key factor is the education of women. That has been directly correlated with reduction in family size. So with improved standard of living with educated women, and with the capacity to take advantage of the technology, we'll probably have smaller families and longer lives.

And, as Dr. Brodsky has pointed out, we now can expect—and I think Dr. Everhart can confirm it—every 1995 graduate can expect to change his or her career at least three times, which means that it's not just retooling, but it means learning a whole set of new kinds of technologies.

MR. BARRAM: The change in life expectancy was fairly gradual for whatever the reason up until now. Do you imagine a pretty dramatic spike given the things that you talked about that are being worked on?

DR. COLWELL: There are some developments that really can be pointed to as enhancing the life span. For example, the discovery of antibiotics and the ability to bring children through many of the childhood diseases. But the dark side is that we face in the next decade perhaps or even 5 years, increased mortality due to standard infections for which we no longer have a pharmaceutical armamentaria because of the excessive improper use of antibiotics and the development of multiple drug resistant drugs, such as TB, streptococcous, pneumonia, et cetera.

As a biologist, I should say that life is a shifting dynamic equilibrium. You move forward. You recalibrate and then you move forward or backwards. So I'm not sure there will be this dramatic spike. I think it will be a continuum. But then my crystal ball may be a little cloudy. That's the best I can say.

I would like to ask a question that's actually posed in the agenda. And that is, in terms of the global growth of technology, is American prepared. Would it be out of place or too forward to ask for a show of hands. Is America prepared? I'd like to see what the opinions are of this group around the table.

MR. WILLIAMS: Not nearly well enough. How about that?

DR. PRABHAKAR: That's a good category. So you want a yes, no, and a not nearly well enough.

DR. COLWELL: I think I would separate it. I feel optimistic. But on the other hand, I really am concerned that we've got some serious, serious problems to overcome.

MR. WILLIAMS: I vote for the position. I'm optimistic always, but I think we're far from prepared to deal with all of the implications that we've been discussing today. We have enormous problems in this society. You can look at the half full, half empty sort of glass. You can assure yourself everything is fine. But I think it's foolishness to assure ourselves that everything is fine.

I don't know when I go home and lock my door with two locks at night and worry about where my wife and I are going to walk around late in the evening, and watch all of these murders and everything on television and on and on and on. I find it hard to affirm this is the ideal society. This isn't what I expected that I would be involved in at this stage in my life. We were doing better by some of these measures 30 years or 40 years ago than we're doing today.

On the other hand, we've accomplished some marvelous things. We're talking about living to 120 years of age and still be in good shape. I can't knock that.

So I think we're somewhere in the middle.

DR. PRABHAKAR: Would anyone like to disagree with optimism coupled with some concerns about key issues? That was broad enough that we got consensus?

MR. GALVIN: The previous discussion should not be examined in the context of what's happening here in the one and only great center of the world, the United States. Remember the other 95 percent of the world.

Our people in Costa Rica and in the Philippines and in Singapore and in India and in Beijing are looking for lifetime careers. And if America thinks it's going to get by uncertainties and discontinuities, again, there is a place where we ought to be pretty pessimistic.

And incidentally, as a corporation, we have confirmed to our people that they can look to our loyalty to them. And we expect their loyalty to us. We're going to build for multiple generations of families serving the corporation as one of our strategies for growing. So there are other contexts in which these things should be done, even though anecdotally we see evidence of a fad at this time. I think that's what it is. That somehow or other we're going to have a lot of bouncing around. I don't think we are. I think things aren't going to change that much in human nature.

MR. BRODSKY: The one area I want to readdress that I think we all should be pessimistic on is the issue of sustainability. I think by many measures we cannot sustain the kind of industrialization we have right now and the kind of population growth. It's not just population growth, but it certainly plays a major role. We are not in balance with the use of raw materials. We don't do full cost accounting in industry, and it's getting worse. We don't account for depletion of natural resources. And I think that's going to take a major change. We're not seeing the end coming. I hate to be like the guy walking around with robes saying, the end is near.

But, in fact, it's going to all of a sudden hit a critical mass and it may be too late for the world to respond if we don't get it now.

DR. PRABHAKAR: I'm glad you mentioned that, because in fact that's a topic we haven't touched on. But it's actually probably worth a whole day's discussion. So, thanks for getting that in the record.

MS. GODFREY: Being pessimistic, the thinking skills bother me the most. I can get lots of people to come in and do computer aided design, but they can't design. I get people who do industrial engineering and they can put out a lot of pretty charts. We can get off looking good in the meeting for a few minutes. But they haven't thought through what that all means. And I think that's more and more occurring is the thinking skills, the problem solving skills.

MR. ROBERT L. CATTOI: Dr. Prabhakar, I think another caution has to do with the development of small and medium sized enterprises. A lot of what we talked about concerned the leading companies like Motorola or UT. The leadership in those companies is pretty good. But there is a disconnect as we get down to the supplier base in the second and third tier companies that we had better consider. We have to develop that base. As Mary said earlier today, that's very, very important.

There is one other phrase that impressed me today. David used the phrase of decision based on evidence. As we looked at the evidence of issues today, such as education, that evidence was either incomplete or irrelevant in some respects. And it was usually dollars thrown at the process. And that's how we measured the goodness or the badness.

There are other dimensions, such as the quality of the process and the quality of the output and the

timeliness of the output, the relevance of the process and the output. And if we don't look at that, we can base our decisions on evidence that really doesn't mean anything. We have to be more careful as we look at that kind of evidence. It has to be information that shows trends, as well as current status. Status is a good snapshot, but it really doesn't tell you what direction you're going, or if that direction is proper.

DR. PRABHAKAR: Thank you for the comment. We sometimes fall victim to the problem that we track those things that are easy to measure, rather than going after the things that are really meaningful. I think that's important.

MS. MACARTHUR: One of the problems that we haven't discussed is the people who will be invisible to this growing society.

I had an opportunity to go to at least two of the meetings that were held after the report, Science and Technology in the National Interest, came out. The idea was that universities would sponsor meetings and invite industry, universities and whatever federal technology institute there would be in that area to come.

The one at MIT was without surprise. The one that was held in Florida where the host of the meeting was the president of Florida A&M, which is a historic black college, was very interesting. Dr. Humphries was sure that most of the historic black colleges in the southeast were there, as well as the other major universities.

The industrial people talked to us. The one who really got me thinking was the manager of the Boca Raton Motorola plant. He was describing criteria for which they would be hiring employees. It was clear that they could not lower their standards. That their policy is that 80 percent of their engineers come from the top 50 engineering schools in the country, of which only two existed in that southeastern part of the United States.

Well, immediately you look around and you see lots of good state universities, but you also see the black colleges and there they are. So where do they come in? At least in surrounds of NASA, money was being spent at black colleges.

And then I realized, if we're going to cut back in our budgets, you begin to see a kind of snowball here. One other person said, and how about training people who are already in the market but have to be retrained. And then somebody said, what about the underclass. Are they invisible totally to this?

I think that if a company like Motorola will hire 80 percent from those kinds of schools they will have to consider those students to be coming with a need for a lot of remediation. They haven't had internships. They haven't had laboratories in their universities.

You can almost see the writing on the wall. I was talking to Mary Good about this earlier. And she said, at some point, society cannot tolerate that we would have this rather large underclass that aren't even in school, let alone, the black colleges that have been aspiring and have been supported by Federal monies that might be cut. We won't be able to tolerate that.

But as we talked optimistically about all of the wonderful things that can happen, we have to realize that right now, that does not include the possibility of a very large segment of our population. This is a problem that will fester and will cause us a lot of trouble and always has to be part of the agenda of something like this.

DR. PRABHAKAR: That comes back to some of the themes we struck earlier in the day. I am going to turn over the mike now to John Yochelson who has very bravely agreed to summarize the discussion.

MR. YOCHELSON: This is a very rich and interesting discussion. I can't possibly do it justice. Arati and I put our heads together. There were three or four themes that stuck out and some defining observations that were made.

The first, made this morning by Dr. Hermann, is that technology is just one component of U.S. leadership, and should not be viewed as the entire solution to all the challenges we face at home or internationally.

The second defining point was made by Dr. Everhart when he observed that we are shifting from a resource driven to a knowledge driven economy, which then put much of the focus on human resources and on whether human resources were adequate. Here today's discussion highlighted a paradox in the relationship between technological leadership and its economic payoff. On the one hand we said that the United States has the wherewithal to lead the technology revolution on a world wide basis. And yet, as Rudy Oswald, Lynn Williams and Gary Burtless' discussion pointed out, somehow this leadership in technology has not delivered the gain in wages and incomes all of us would like to have seen. We seemed to conclude that the investment we are making as a society is enough to enable us to lead in technology, but it is insufficient to address the dislocations in income and employment that we are finding along the way.

In the afternoon, we talked mostly about some of the constraints on U.S. technology leadership. Dr. Colwell and Ms. MacArthur talked about some financial constraints. They talked about human resources constraints to the U.S. situation.

And then Bob Galvin turned the thing around by arguing that much of what we have been worried about, financial constraints in terms of federal support, may be less and less relevant if the private sector does indeed grow as he foresees.

And Mr. Galvin brought us back to where Dr. Hermann started the day by arguing that the heart of resolving and building a position of strength in the United States lies in capturing the global markets and global opportunities. In effect, there is no conflict between the national interest and the international strategies of our most important companies.

# Appendix C:

## Biographies of Speakers

Dr. Robert J. Hermann
Senior Vice President, Science and Technology
United Technologies Corporation

Degrees: Bachelor of Science, Master of Science, and Ph.D. in electrical engineering from Iowa State University

Dr. Robert J. Hermann was elected senior vice president, science and technology at United Technologies Corporation in July 1992. In this position, Dr. Hermann is responsible for assuring the development of the company's technical resources and the full exploitation of science and technology by the corporation. He also has responsibility for the United Technologies Research Center. Dr. Hermann joined the company in 1982 as vice president, systems technology in the Electronics sector and later served in a series of assignments in the Defense and Space Systems groups prior to being named vice president, science and technology at United Technologies Corporation in March 1987.

Dr. Hermann served 20 years with the National Security Agency with assignments in research and development, operations and NATO. In 1977, he was appointed principal Deputy Assistant Secretary of Defense for Communications, Command, Control, and Intelligence. In 1979, he was named Assistant Secretary of the Air Force for research, development and logistics and in parallel was Director of the National Reconnaissance Office. In 1981, he was named special assistant for intelligence to the Under Secretary of Defense for Research and Engineering.

Dr. Hermann is a member of the President's Foreign Intelligence Advisory Board; the Defense Science Board; the National Academy of Engineering; the Visiting Committee on Advanced Technology of the National Institute of Standards and Technology; the National Research Council Commission on Physical Sciences, Mathematics and Applications; and the National Society of Professional Engineers Industry Advisory Group. He is a member of the Board of Directors for Draper Laboratories, and the American National Standards Institute; Board of Trustees for the Hartford Graduate Center.

Thomas E. Everhart
President
California Institute of Technology

Degrees: A.B. degree in physics in 1953 from Harvard University, Ph.D. degree from the University of California at Los Angeles in 1955, Ph.D. in engineering from Cambridge University, Cambridge, England, in 1958.

Dr. Everhart is also a Professor of Electrical Engineering and Applied Physics. He is a Magna cum laude graduate of Harvard University.

Dr. Everhart joined the University of California at Berkeley in 1958, where he served in the Department of Electrical Engineering and Computer Science for more than 20 years. In addition to teaching and research, he also served as chairman of the department during 1972 to 1977. In January 1979, he became dean of the College of Engineering at Cornell University, Ithaca, New York. In August 1984 he left Cornell to assume the chancellorship at the Urbana-Champaign campus of the university of Illinois where he remained until accepting the presidency at the California Institute of Technology in September 1987.

Dr. Everhart is a national spokesman on science and technology. He has served on the National Academy of Engineering Council and Executive Committee, and is on the Board of Directors of the Corporation for National Research Initiatives. He has previously chaired the Secretary of Energy Advisory Board, General Motors Science Advisory Committee, the National Academy of Engineering Committee on Membership, and the Lawrence Berkeley Laboratory Scientific and Educational Advisory Committee. He has served as Chairman of the Council of Presidents, Universities Research Association, and currently serves on its Board of Trustees.

His main areas of interest and expertise have been in the research and development of scanning electron microscopes, electron beams as applied to semiconductor analysis and fabrication, and basic science and engineering related to these subjects. In 1984, the Institute of Electrical and Electronics Engineers honored him with its Centennial Medal, which recognizes outstanding achievements in electrical and electronics engineering. In 1989 he received the Benjamin Garver Lamme Award from the American Society for Engineering Education. The University of California at Berkeley awarded him the Clark Kerr Award recognizing his contributions to the advancement of higher education in May of 1992 and the Founder's Award in April of 1995 from the Energy and Resources Group at Berkeley.

Throughout his academic career, Dr. Everhart has maintained a close relationship with industry. He is a member of the Board of Directors for General Motors, Hewlett-Packard, Reveo, and KCET. He has been a member of the R. R. Donnelley Technical Advisory Council, a consultant to such firms as Ampex Research and Development Laboratories, Bell Laboratories, Hughes Research Laboratories, IBM Research Laboratory, Watkins-Johnson Company, and Westinghouse Research Laboratories. He presently serves as Vice President and as a member of the Executive Committee of the Council on Competitiveness.

Dr. Everhart has strong international ties. He was a Marshall Scholar at Cambridge University, England, while pursuing his doctorate, and has been a visiting professor or fellow at the Institut fuer Angewandte Physik, Tubingen, West Germany; Waseda University, Tokyo; Osaka University; and Clare Hall, Cambridge. He has served on review committees for RIKEN in Japan and for the

Australian National University.

He is a member of many scholarly and honorary societies including Phi Beta Kappa, Sigma Xi, American Association for the Advancement of Science, National Academy of Engineering, Bohmische Physikalische Gesellschaft, Institute of Electrical and Electronics Engineers, and the Electron Microscopy Society of America. He has held a Guggenheim Fellowship and a National Science Foundation Senior Postdoctoral Fellowship. He was elected a Fellow of the American Association for the Advancement of Science, a Fellow of the American Academy of Arts and Sciences, and a Foreign Member of The Royal Academy of Engineering (Great Britain). He has three honorary doctorates.

Dr. Everhart and his wife, Doris Arleen (Wentz), have four children—Janet Sue, Nancy Jean, David William, and John Thomas—and four grandchildren. Office address: Office of the President, California Institute of Technology, Parsons-Gates Hall of Administration, Room 204, Pasadena, California, 91125.

Gary Burtless
Brookings Institute

Degree: Graduated from Yale College in 1972, Ph.D. in economics from Massachusetts Institute of Technology in 1977.

Gary Burtless is a Senior Fellow in the Economics Studies program at the Brookings Institution in Washington, DC. He does research on issues connected with public finance, aging, saving, labor markets, income distribution, social insurance, and the behavioral effects of government tax and transfer policy. He is coauthor of *Five Years After: The Long Term Effects of Welfare-to-Work Programs* (Russell Sage, 1995), *Growth with Equity: Economic Policymaking for the Next Century* (Brookings, 1993), and *Can America Afford to Grow Old? Paying for Social Security* (1989), editor and contributor to *A Future of Lousy Jobs? The Changing Structure of U.S. Wages* (1990) and *Work, Health and Income Among the Elderly* (1987), and the author of numerous articles on the effects of Social Security, welfare, unemployment insurance, and taxes. His recent research has focused on sources of growing wage and income inequality in the United States, the influence of international trade on income inequality, the job market prospects of public aid recipients, and reform of social insurance in developing countries and formerly Communist economics.

Before coming to Brookings in 1981, he served as an economist in the Office of the Secretary of Labor and the U.S. Department of Health, Education, and Welfare. In 1993 he was Visiting Professor of Public Affairs at the University of Maryland, College Park.

Diana MacArthur
Dynamac Corporation

Mrs. MacArthur is the Chair, Chief Executive Officer, and Co-founder of Dynamac Corporation, a firm providing integrated environmental services: environmental health and sciences consulting, natural resources management, and hazardous waste engineering. She has 35 years of experience in public policy and program development, spanning industry, the Federal Government, nongovernmental organizations, and academia. Previously, she was President of a Dynamac subsidiary (merged in 1980) engaged in technology transfer, training and education, public outreach, and communications in areas of the environment, health, and safety.

Earlier in her career, Mrs. MacArthur was the manager of the prevention arm of a multimillion dollar national clearinghouse for health information and education, operated by General Electric under a Federal Government contract. In early days of the Peace Corps, she served as Director of its Office of Private and International Organizations. And she was Vice President and Director of the Washington office of the Thomas J. Deegan Company, a public relations firm in the InterPublic group.

Mrs. MacArthur is active in public affairs. Currently, she serves the Federal Government in two capacities. Appointed by President Clinton, she is a member of the President's Committee of Advisors on Science and Technology (PCAST). She is a member of the Environmental Technologies Trade Advisory Committee of the U.S. Department of Commerce. In the past, she was a member of the Citizens Advisory Board to the President's Council on Youth Opportunity.

In the realm of nongovernmental organizations, Mrs. MacArthur is on the Advisory Board to the Center for Strategic and International Studies (CSIS), where she served on the Strengthening of America Commission and on the National Laboratories Steering Committee, a group that studied ways to enhance cooperation between the Department of Energy national laboratories and industry to commercialize technology critical to American economic growth and competitiveness. At present, she is a member of the CSIS Senior Policy Group on National Grand Challenges, a new project to identify the R&D priorities for the first quarter of the 21st century. Mrs. MacArthur is a Director of the Atlantic Council. She is also a member of the Advisory Council to the Committee for the National Institute for the Environment, and is an associate of the North American Institute, a think tank that deals with such issues as the North American Free Trade Agreement and the establishment of a North American Environmental Council. Since 1970, she has been a trustee of the Menninger Foundation.

In the academic arena, Mrs. MacArthur is a member of the Board of Visitors of the University of Maryland Biotechnology Institute and serves on the Chancellor's Advisory Council of the University of Maryland System. In addition, she is a member of the Board of the University of Maryland Foundation, Inc.

Mrs. MacArthur holds a B.A. in Economics from Vassar College, where she was elected to Phi Beta Kappa. She is the recipient of the 1993 *KPMG Peat Marwick High Tech Entrepreneur Award*, which honors individuals who have made significant contributions to the community and to the advancement of the high technology industry.

Rita R. Colwell
President
University of Maryland
Biotechnology Institute

Birthplace: Beverly, Massachusetts

Degrees: Bachelor of Science, Bacteriology, Purdue University; Master of Science, Genetics, Purdue University; Ph.D., Marine Microbiology, University of Washington

Microbiologist and marine scientist, active in national and international research and teaching. Has focused much of her research on marine biotechnology and the molecular genetics of marine and estuarine bacteria, and on the microbiology of the Chesapeake Bay, coastal recreational waters, and the deep ocean. Presidential appointee to the National Science Board of the United States. Professor of Microbiology, University of Maryland at College Park, under whose leadership the University's Sea Grant Program was designated a National Sea Grant College in 1983. Currently President of the University of Maryland Biotechnology Institute, a major research unit/campus of the University of Maryland system. Past President of the International Union of Microbiological Societies. Author or coauthor of 16 books and more than 450 scientific publications. Consultant to the Government, universities and industry, and invited participant in many international symposia. Awarded Honorary Doctor of Science by Heriot-Watt University (Edinburgh, Scotland) in 1987, by Hood College, Maryland, in 1991 and by Purdue University in 1983, D.LLD by Notre Dame College of Maryland in 1994, and the Andrew White Medal by Loyola College in 1994. Made Honorary Professor, The University of Queensland (Queensland, Australia), 1988. Member, Alumni Advisory Committee, School of Science, Purdue University, 1993-1996. Chairman, Waterman Committee, National Science Board, National Science Foundation, 1993-1994. Served as President of the Sigma Xi National Science Honorary Society and is currently Chairman of the Board of Governors of the American Academy of Microbiology and Chairman of the Biological Sciences Section of the American Association for the Advancement of Science, as well as Fellow and President, AAAS; Leadership Maryland 1995.

Robert W. Galvin
Chairman of the Executive Committee
Motorola, Inc.

Bob Galvin started his career at Motorola in 1940. He held the senior officership position in the company from 1959 until January 11, 1990, when he became Chairman of the Executive Committee. He continues to serve as a full time officer of Motorola.

He attended the University of Notre Dame and the University of Chicago, and is currently a member and was the recent chairman of the Board of Trustees of Illinois Institute of Technology.

Bob Galvin has been awarded honorary degrees and other recognitions, including election to the National Business Hall of Fame and the presentation of the National Medal of Technology in 1991.

Motorola is the first large company-wide winner of the Malcolm Baldrige National Quality Award presented by President Ronald Reagan at a White House ceremony in November 1988.

# Appendix D:

## List of Attendees

William Archey
President
American Electronics Association

James Auerbach
Vice President
National Planning Association

Gary Bachula
Deputy Under Secretary for Technology
Department of Commerce

David J. Barram
Deputy Secretary
Department of Commerce

Wilmer R. Bottoms
Senior Vice President
Patricoff & Company

Philip Brodsky
Director, Corp. Res. & Envir. Tech.
Monsanto Company

Gary Burtless (speaker)
Senior Fellow
Brookings Institution

Charles F. Carter
Vice President, Technology
Association for Manufacturing Technology

Robert L. Cattoi
Technical Consultant to the Office of the Chairman
Rockwell International

Lawrence Chimerine
Managing Director and Chief Economist
Economic Strategy Institute

Joseph F. Coates
President
Coates & Jarratt, Inc.

Rita Colwell (speaker)
President
American Association for the Advancement of Science

Thomas Everhart (speaker)
President
California Institute of Technology

Robert Galvin (speaker)
Chairman of the Executive Committee
Motorola, Inc.

Jacques Gansler
Executive Vice President
TASC

David Godfrey
General Manager
Manufacturing Resources, Inc.

Mary L. Good
Under Secretary for Technology
Department of Commerce

Victoria F. Haynes
Vice President, Research & Development
The BF Goodrich Company

L. Louis Hegedus
Vice President, Research Division
W.R. Grace and Company

Robert J. Hermann (speaker)
Senior Vice President, Science and Technology
United Technologies

Fred Kittler
Vice President
J.P. Morgan

Charles Larson
Executive Director
Industrial Research Institute

Diana MacArthur (speaker)
Chair and CEO
Dynamac Corporation

Mary McCain
Executive Vice President
American Society for Training and Development

Graham R. Mitchell
Assistant Secretary for Technology Policy
Department of Commerce

Bill Morin
Director, Technology Policy
National Association of Manufacturers

Van Doorn Ooms
Senior Vice President, Director of Research
Committee for Economic Development

Rudolph Oswald
Director of Research
AFL-CIO

Rusty Patterson
Industry President and CEO
Agility Forum

Gordon Pavy
Industrial Union Department
AFL-CIO

Curtis E. Plott
President
American Society for Training and Development

Arati Prabhakar (co-chair)
Director
NIST

Howard Rosen
Executive Director
Competitiveness Policy Council

Robert J. Saldich
President and CEO
Raychem Corporation

Gregory Tassey
Senior Economist
NIST

James Van Erden
Senior Vice President
National Alliance of Business

Albert R.C. Westwood
Vice President, Research & Exploratory Technology
Sandia National Laboratories

Lynn Williams
President (ret.)
United Steelworkers of America

John Yochelson (co-chair)
President
Council on Competitiveness

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