SUMMARY OF U.S. PAPERS AND COMMENTARY

Dale R. Corson

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Since world War II the United States basic research operation has been characterized by a partnership between the academic world and the federal government, with more than half the basic research performed in the universities. At the same time major industrial concerns have supported large and important central research laboratories. Companies falling in this category include the Bell Telephone Laboratories, the General Electric Company, Westinghouse, The Radio Corporation of America, the Corning Glass Company and the major pharmaceutical companies such as Upjohn, Squibb, Pfizer and others.

Research support in the universities has been provided by a diverse group of federal agencies including the National Science Foundation, the National Institutes of Health, the Office of Naval Research, the Office of Scientific Research in the U.S. Army, the Advanced Research Projects Agency in the Department of Defense, the United States Department of Agriculture and several other agencies with smaller research budgets. Relatively little support for basic research in the universities has been provided by industry, probably no more five or six percent of the university total.

One of the principal features of this system has been the combination of graduate education with the research effort in the universities. The primary function of the research faculty in the universities has been to teach students to solve difficult, novel problems by apprenticing the students to investigators who themselves are solving difficult novel problems. In the process some of the best research in the world has been accomplished.

Over the past ten or twenty years this system has begun to change and its effectiveness has eroded. In the first place the cold war ended and national security is no longer the driving force behind the basic research effort and the support has faltered. While this has gone on, large federal deficits have developed when governmental fiscal policy changed during the Reagan and Bush Administrations. The country, and the world, has been hit by a deep and persistent economic recession in recent years, further pressuring the availability of funds for research purposes. On top of everything else the emergence of other countries, primarily Japan, as dominant world economic powers has taken away markets and shifted the focus of research and development emphasis in the country.

The result of these combined forces over the past decade or two has been to shift the emphasis from basic research to development of products and processes that have quick economic payoff and to shift the research emphasis toward directed ends perceived to have strategic advantage in confronting the industrial competitive problem presented by Japanese, German, Southeast Asian and other new economic giants.

American industry has found itself faced with declining markets and the requirement to reorganize itself, often into smaller decentralized units, with a consequent decline in the importance of the centralized, high quality research laboratory. The result has been loss of the ability

to provide the large amount of basic research that undergirded American industry's economic dominance.

While all this has been going on the stature of American universities and their perceived importance in the whole American economic scheme has been undermined by a series of developments that threaten their effectiveness in the future. Foremost among these developments has been the rise in cost of doing research, as well as in the cost of providing education to the undergraduates they also serve.

The American research scene has also witnessed a certain amount of fraud, including both scientific fraud in the reporting of research results and financial fraud in the stewardship of governmental funds intended for research. All these factors, while they have characterized a minuscule portion of the entire effort, have combined to undermine the public confidence in the universities, leading to a growing reluctance to provide support in adequate amounts.

For most of this century the cost of American higher education, including the cost of doing research, has increased two or three percent, on the average, faster than the rate of increase that has characterized the general inflation rate in the economy. The most readily evident part of the rising cost has been an ever larger fraction of the total cost of doing research going to "indirect costs", i.e. to the "overhead" costs of doing business--the supporting services and supplies. Much of the relative increase in indirect costs has arisen from governmental regulations requiring increased attention to worker safety, to the care of animals used for research purposes, to supervision of the use of human subjects for research purposes, from environmental pollution control and from many other research-related activities mandated by governmental regulations.

Rising indirect costs and pressure to contain them have led to assumption of more and more of the costs by the universities themselves, with the money to cover the costs coming from the tuition undergraduates pay in the case of private universities or from public appropriations in state-provided budgets in the case of public universities.

At the same time that the indirect costs have risen the direct costs of doing research have also risen as the research has become more complex and the facilities and instruments required have increased in cost at a rate that has also exceeded the general inflation rate.

The response of the universities to the growing public pressure to contain the costs and to eliminate whatever fraud exists in the system has sometimes further eroded public confidence. The universities believe that if they are to serve the public through the provision of high quality research and the education of graduate students the public should reimburse the universities for the costs. Unfortunately, university perception and public perception of what the real costs are diverge widely.

The "public" in this situation is most directly the United States Congress which is much the most important institution in the provision of public funds for research purposes. The result is that Congress is now in the "driver's seat" and there is a broad gap between university and congressional perceptions of the problems. Confidence has been lost and it will take time to heal the wounds.

These developments over the past ten or twenty years have left a number of important but unanswered questions concerning the future of the American research effort. I can list some of the questions here but I do not know the answers.

Who is going to do the research that the high-tech economy we are developing around the world requires for future development? There is a wide-spread conception in the United States that Japan has based its highly successful high-tech developments on American basic research. If American research falters will Japanese high-tech industry also falter? American industry is cutting back its own research concentration for a number of reasons and the universities appear to be in no position to produce results as they have in the past. It is a problem.

Can high-tech development continue to thrive on the reservoir of basic research results which now exists? Is there a sufficient body of results available in our libraries and in our scientific journals to sustain us into the foreseeable future with the diminishing replacement rate we think we see now? I doubt it.

As research funds become less available there will be inevitable pressures to support research projects which are perceived to have the most economic potential. By adopting a policy of such directed research in an effort to make the research dollars go farther are we jeopardizing the future? I tend to believe that the answer is "yes". Some twenty or more years ago The National Science Foundation conducted a study called "TRACES" which sought out the research origins of a number of economically important new technologies, such as the contraceptive pill and the laser. The study found that the economically important development had its roots in every case in a broad base of fundamental research, often in many different fields, all of them vital to the eventual development of the product in question. Had someone begun a search 100 years ago targeted narrowly on a contraceptive pill it would have been unlikely to succeed. Only by bringing together an array of results across many fields was the final product realized.

Can universities and industry form partnerships of sufficient capacity and relationships to provide, between them, the essential basic research? In the United States this has not happened in the past. It is becoming of more interest now given the rapid development in some fields and the inability of industry to provide the wide ranging research required. The new field of biotechnology is perhaps the best example. Much of the important work has been done in universities and industry must have "windows" into the university work so that partnerships and cooperative efforts have developed in many places. Monsanto with Washington University in St. Louis is one example. The large German pharmaceutical firm Hoechst and Massachusetts General Hospital in Boston is another. It seems to me that this avenue must be pursued vigorously.

Will graduate education and research continue together as they have in the past in the United States? This practice is by no means required for research success, witness the German Max Planck Institutes where much of the research is performed and which are only loosely tied to the universities. The Japanese universities have not played nearly the important role in performance of research and the training of investigators that the universities have played in the United States. It seems now that American research and graduate education will continue closely tied together but the situation could change.

Can American universities contain the costs, not only of supporting research but also of providing education to undergraduates? It is going to be difficult in the extreme. We have 125 or 150 years experience doing things the way they are done now and it will be hard to change. It seems to me, however, that we must find new ways of containing costs if we are to survive in a vigorous state. We must find ways to abandon the old things we do so that we can undertake the new things that society demands of us.

Can we continue to attract the brightest and the best of our young people to science and technology? This is by no means certain, in my mind. We fail to attract significant numbers of women in many fields, physics and mathematics, for example. We have a large minority population and, with the exception of Asians, we are not attracting them to technical fields. We are missing large reservoirs of talent that we will surely need in the future. In my opinion not enough effort is directed in this direction.

How can we rebuild the infrastructure that supports our research effort? Following the launching of the Soviet Sputnik in 1957 there was great emphasis on science and technology in the United States, lest we lose the economic and intellectual war to the Soviets. Facilities and research equipment that were provided by the government served us well for many years. Now there are few programs to replace the aging facilities and the out-moded instruments. The only place replacements can come from, other than those that industry can provide for itself, is the government and there is little motion in that direction. This seems a big problem to me.

I have outlined here the nature of the large problems we have heard about from those on the American side who have presented their views to us. I have also given brief commentaries on where I see the United States standing at the moment and where I see it going. I believe that the future of the entire world's high-tech industry depends to a considerable degree on how we in the United States deal with these problems. I believe it is important that the Japanese in particular contribute a larger share of the basic research we require for the future. I hope we can approach these problems cooperatively and work together for the welfare of the entire world.