Committee I
The Limits of Science?

DRAFT--6/15/91
For Conference Distribution Only

POLICY CONSEQUENCES OF THE LIMITS OF SCIENCE

by

John Holmfeld
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, D.C., USA

The Eighteenth International Conference on the Unity of the Sciences
Seoul, Korea August 23-26, 1991

The Limits of Science
International Conference On The Unity Of The Sciences
Seoul, Korea, August 1991

THE POLICY CONSEQUENCES OF THE LIMITS OF SCIENCE

by

John D. Holmfeld

Beyond the world of science itself, what are the effects of the limits of science? Outside the laboratory walls and the science classroom what does society know about the limits of science and how does society react to those limits? What are the views of policymakers, acting in the interest of society, concerning the limits of science and what are the consequences of those views for the polices they formulate and pursue, promulgate and fund, amend and abandon?

In taking a careful look at that question, the first aspect to recognize is that in the political world the concept of limits in the world of science is largely unrecognized. The generation of policymakers which today addresses the broad range of issues in science policy, view science as an enterprise almost without limits. They came to maturity as policymakers in the post-World War II and post-Sputnik years, the decades of the fifties and sixties, and they achieved power and influence in the policy process in the seventies and eighties. Those decades, especially the last two since Sputnik, were characterized by a view of science as an endeavor as having no limits. Research would move forward, the frontiers being pushed further and further out into the unknown without limits; and the technological applications based on those research results would continue to emerge, limited only by man's ability to translate science into technology.

To be sure there were instances which came to be seen as the misuse of science, as going beyond the acceptable limits. There were specific cases where science itself went too far, such as the medical experiments on humans in Nazi Germany, and the rare cases of behavioral experiments misusing men and women in experiment on human behavior. And there were technological applications of science, such as the atomic bomb and agricultural pesticides, where the balance between benefits and costs was debated by proponents and opponents. But those instances were viewed by most policymakers as aberrations, as exceptions that confirm the rule that science has no limits.

Because science was viewed as having unlimited potential for both continued internal growth and for yielding a steady stream of societal benefits, policymakers also accepted the idea that society should not place any limits on science. In occasional instances society or even scientists themselves might have to impose limits on scientific research. But such regulation had to be done with great care, and the assessment and balancing of benefits and costs had to avoid the overreaction to short-term problems so as not to loose sight of the long-term benefits. Scientists were invariably concerned that regulation in one small area might open the door to additional regulations in other areas, and that view was generally accepted by policymakers.

In general, however, individual scientists should be unfettered to pursue scientific research in whatever direction it takes them, and should be provided with the resources of time, equipment, and supporting services to do their scientific research. In the extreme manifestation of this view, society should make it possible for every new idea to be pursued, and society had an obligation to support every scientist who had the ability and training to perform research, as evidenced by the achievement of an advanced degree in science.

The political world's view of science as being without limits was reinforced by the members of the scientific community whenever they had contacts with policymakers. In contrast to technological developments, which are now understood to be subject to some limits, most scientists argued during these years that scientific research should be carried out without any limitations, internal and external. That view, closely tied to the idea of academic freedom, came to have the status of a norm guiding the behavior of scientists. This norm is still so strong that on those rare occasions when an individual scientist speaks out, suggesting that there are inherent limits of science that should be taken into account or that there are societal effects of science that should be weighed, that scientist is considered to have violated the norms of behavior for scientists, and sanctions of various forms are imposed.

The question we now face, stimulated by the provocative question posed by the conveners of this conference, is whether that perception of science as having no limits is changing and if so, what the effects of such a change are. Do the occasional instances which I have alluded to portend the beginning of a trend? Is that perception on the part of policymakers about to undergo a noticeable change, and will it, like a pendulum, swing past a neutral centerpoint to the opposition extreme? Will we, 10, 20 or 30 years from now see policymakers taking the view that, generally speaking, science must be dealt with as an enterprise with distinct limits?

It can be difficult to envisage such a dramatic shift in attitude and perception, and it is therefore worth recalling that such shifts have occurred before in other but related fields. A notable, quite recent example is the view held by policymakers in Western countries of the role of the military in society. Forty-five years ago, following the end of World War II, the military was viewed very much as science is viewed today: it was an activity which every society must have; its practitioners were experts whose judgement on military matters were highly respected and rarely questioned, and the judgement of these experts about the resources needed by the military was widely accepted. Only when the admirals and generals disagreed among themselves did civilian policymakers find themselves called upon to step in and referee the dispute, and they did so with reluctance, fearing that their lack of expertise would lead to bad decisions and consequently to political trouble.

Today this view of the military has undergone a dramatic change. Policymakers in most countries, while still supportive of the military in general terms, are involved in the details of military policy, such as the selection of weapons systems, and the charting of military manpower policy. And, significantly for our purpose, civilian policymakers are thoroughly acquainted with the limitations of military power both in terms of what military capability can and cannot accomplish, and in terms of the constraints that can and must be imposed by the political world on the military.

Will a comparable shift take place in the policymaker's view of science as a universally beneficial activity which has no inherent limits? Let us first look at the limits of science itself. Here the basic question is whether the rationale for continued, strong financial support of science by policymakers will continue to be accepted, or whether, to an increasing extent, the several limits of science will become more visible to policymakers and influence policy formulation. Today, that acceptance is based on an understanding that there are some inherent limits within science but that these limits are not sufficiently detrimental to outweigh the advantages that science can yield.

Let us first note that the rationale for society's support of science is multifaceted. It consists of several different reasons for why society should support science. One is cultural. Any country which has attained a certain level of civilization should support the search for truth about the nature of the natural world for the same reason that such societies support art and literature, music and theater, dance and poetry. Few today question that rationale. But by no stretch of the imagination can the level of support for science today be justified for that reason. In my own country something on the order of between 5 and 10 percent of the budget for basic scientific research can perhaps be justified as a cultural activity. The remainder must be supported for other, quite different reasons.

Another facet of the rationale for the support of scientific research is that it serves as an important ingredient in the training of new scientists, especially at the higher levels of graduate and post-graduate education. The last step in the education of young scientist is to work as an apprentice under the guidance of a mature scientists actually engaged in research. Here again this is a sound reason for policymakers to provide support for scientific research. But only a fraction of the current support level can be justified as necessary to support the advanced training of young scientists. It is worth noting in this connection that one of the characteristics of science policy up to now is the absence of any quantitative analysis of just what the level of research and research support should be to train young scientists in the different disciplines as distinguished from the much larger volume of research that is done without any ties to advanced research training.

This brings us to the third rationale for the support of science, the expectation that it will lead to practical results. Scientific research has led to new technologies and new manufacturing processes, new cures for illness and new ways to prevent the spread of disease. Therefore it is effective and worthwhile for society to encourage and support scientific research. The great bulk of research supported by society must be supported on the basis of this rationale.

The question we now ask is this: Are there limits within science which, in terms of the ability to yield technological pay-off, should, from the point of view of policymakers, be taken into account in allocating resources to science?

One of the remarkable facts of modern science policy is that there is already a quite sophisticated understanding among policymakers who have specialized in science policy of some of the inherent limits of science with respect to the ability to yield technological advances. But other limits are now beginning to appear on the radar screens of policymakers, and may well lead to a reassessment of the manner and level at which science is supported by society.

One well-understood limitation is the inability to predict which research project will lead to technological pay-off and which will not. When a particular research project is begun not only may it be difficult to predict the scientific outcome, it will also in most cases be nearly impossible to predict whether those scientific results will lead to a practical, technological application usable in society.

There is a further limit which is well understood by policymakers. For those scientific advances which do in fact produce a technological pay-off, one can not predict how soon it will be attained. In some cases the pay-off comes immediately or within a few months; in other cases the pay-off comes 10, 20, or 30 years after the scientific advances has been achieved.

These two limitations, the uncertainty of pay-off and the time to pay-off have, as I noted, been well understood by those responsible for the financial support of science. It is now becoming clear that there are other limitations in science which are less well understood among policy policymakers and which piay a role in the degree to which technological or scientific pay-off is obtained from science.

One such limit has always been vaguely known but has not been widely translated into government policy. This is the fact that research in certain fields and subfields of science is more likely to produce technological pay-off than research in other fields. Conventional wisdom, based on often startling anecdotal evidence, is quite to the contrary; namely that research projects in one field can lead to technological pay-off in an unexpected and entirely different field. On the basis of this view, many policymakers, focusing on such specific fields as agriculture or energy, have gradually broadened the research that is being supported for those purposes. But the lesson of industrial research laboratories is likely to become better understood and more widely implemented in the wider society: namely, that such instances are not typical.

In consequence, more and more policymakers are likely to appreciate that further increases in the support of scientific research should not be made indiscriminately on an across-the-board basis, but with a much higher degree of selectivity. While all the disciplines and subdisciplines of science will continue to need support as cultural activities and in order to train new generations of scientists, that large portion of science which is being supported in the expectation of technological payoff must be focused and based on the probability of such payoff.

Yet another, related, limit of scientific research activity is now beginning to surface in the minds of policymakers. Again, it is a limit which is vaguely understood and which is not today translated into science policy to the degree that it is likely to occur in the future. I have just noted that growing appreciation of the need to differentiate between the levels of probability that attaches to different areas of science in terms of technological pay-off. A similar distinction will increasingly have to be made in terms of scientific payoff.

The classical model of the scientific enterprise is that of a brick edifice under construction. Today's researchers build on the bricks of knowledge contributed by past researchers, and future researchers build on the contributions made by today's scientists. The Kuhnian paradigm view suggests that occasionally a wing of that edifice which under construction is abandoned in a favor of the construction of a new wing. But basically the idea of each research project contributing yet another brick of knowledge to the edifice of science prevails.

Policymakers will in the future be asking how many of the research projects for which they are providing the resources do, in fact, produce scientific results that constitute bricks in the edifice of science, that is, to what extent are the results yielded by past and present research projects used as stepping stones by the scientists of today and tomorrow and how many are not?

The coming debate concerning the effects on science policy of all of these limits will no doubt be intense. If the past development of science policy is any guide, it will be characterized by a search for anecdotal evidence that can buttress the various views of the relevance of each limit to policymaking. In those circumstances it will be highly desirable that the policy debate be supplemented by a strong component of quantitative analysis, a form of analysis which has been singularly lacking from the field of science policy formulation in the past.

It would be my guess that the widespread perception among policymakers of the additional limits of science will be reached quite suddenly. A critical event or the public statement by a highly respected figure will receive wide attention and, like a paradigm shift within science itself, the perception among a wide range of policymakers, not just those closely associated with policymaking for science, will undergo a shift. In one major industrial country the shift in that direction has already taken place. In Great Britain, during the decade of the Thatcher administration, policymakers have taken a number of steps which appear to reflect a substantially increased appreciation of the many limits of science.

However, it must be noted that those steps have been dictated not solely by an appreciation of the limits of science, but also by the reality of budgetary constraints. The cost of supporting science has gone up steadily and policymakers have, as a result, been forced to place a limit on the growth in funding for scientific research.

A factor that will contribute strongly to this wider understanding of the limits of science is the need to establish priorities within the science budgets of governments. That need arises from the growing cost of research in many fields, from the growing number of scientists asking for financial support, and from the inability of many governments to make substantial increases in their science budgets due to other demands. As a result of this need to grapple with science priorities, policymakers will look for ways to select those people, projects, and programs which are most likely to achieve the desired purposes.

In that calculus an understanding of where the limits of science are comes into play and will play a significant role. And the application of that understanding and the resultant effects throughout the scientific community will lead to a wider appreciation both among policymakers and in society as a whole of the limits of science.

The effect of such an enhanced perception of the limits of science will probably not be unlike the change that occurred in policymaking for defense. Public and political support for science will remain strong, but there will in all likelihood be a deeper involvement by policymakers in priority setting within science and in monitoring and measuring the pay-off from the substantial investment of the taxpayers dollars in scientific research.