Committee I
The Limits of Science?

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DISCUSSION REMARKS

by

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Response to **Alvin M. Weinberg's**

LIMITS OF SCIENCE FOR POLICY AND POLICY FOR SCIENCE

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COMMENTS (*) ON ALVIN M. WEINBERG'S PAPER:

LIMITS ON SCIENCE FOR POLICY AND POLICY FOR SCIENCE

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Funding limit

Weinberg considers science policy in a national context. There are a number of public issues like health, defense, education and the environment which require attention and action. The appropriate agencies undertake mission oriented R&D for the purpose of solving current problems. In order to do this well and to anticipate long-term and unforeseen developments Weinberg suggests that such agencies should do a certain amount of basic research as a kind of 'overhead'. On looking at the figures for mission-agencies in the US, Weinberg finds little regularity in the ratios of expenditure on applied R&D to expenditure on basic science.

I don't think this will surprise us. An analysis of the R&D efforts of private companies will reveal a similar phenomenon. Numerous attempts have been made - but all in vain - to relate a company's success to the amount of R&D it does,or to the ratio of free R&D to dedicated R&D. The wisdom acquired from such studies is: doing too much is wrong, although there are some noteworthy exceptions in a certain time-frame for certain companies. On the other hand doing too little is wrong also, although there are some... and so on. There is no unique optimum.

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basic research in EIRMA member companies

The second idea that Weinberg presents in his paper, is that mission-related R&D plus 'overhead' has to be supplemented by a national 'culturally motivated' basic science mission; in the US this is the responsibility of the NSF. My comment here would be that once you support interesting science, there is always the unforeseen possibility or even desirability of an application-oriented follow-up. Quite often this is best done by the same people in the same environment. Otherwise the chances of succes are small. If this undertaking is to lead to succesful innovation (production and market penetration), one needs some application-oriented stimulation and guidance. Basic researchers need encouragement to activate user interest. So even NSF-like agencies need a mechanism whereby possible applications of their research can be promoted. Unless some agency employees are alert to the possiblities of utilization, brilliant science may be done, but economic or other benefits will be harvested by outsiders.

The issue of which part of the GNP of nations should be spent on R&D and which part on basic science in particular is also touched upon in John Holmfeld's paper. I shall say more about it in my comments on that paper.

Like all citizens scientist have a right to campaign for a better share of the cake. The loss of vigor in scientific enterprise that is already occurring due to a lack of funding (Lederman) is a convincing argument. Young people are turning away from science because it does not offer financial security. It is a sobering thought that, according to Weinberg, there has been almost a 50% reduction in the number of nuclear engineering degrees awarded in the US between 1977 and 1987. One wonders about the safety of nuclear power plants in the future. Weinberg ponders on science as a way of life rather than a way to make a living. The former would certainly reduce the number of grant applications! However, I doubt whether big science could be organized that way. And because basic science is the best training ground for researchers, I do not think that sufficient numbers of properly trained people would then become available to carry on the mission-oriented R&D and the other tasks in society for which such a training is a prerequisite.

Trans-scientific limit: Regulators dilemma

Weinberg mentions radiation and nutrition as examples of trans-scientific problems, in that they cannot yet be solved entirely by scientists. Climate change, carcinogens and effects of exposure to radon are other areas where scientists disagree and the regulator faces dilemmas. Trans-science is divided into subjects we do not yet know enough about and subjects that will remain unreal and unscientific. Truth emerges in the course of time, not when the issue arises. Things that were considered impossible at a certain time prove possible or are believed to be possible later or vice versa; even 'absolute' truth is sometimes disproved!

The paper contains a very interesting discussion of the problem of the risk involved in new technology.

Two minor comments - to add to Weinberg's examples.

Firstly, toxicity and level of exposure are always linked. Vitamin A and ordinary salt, sodium chloride, are only two of the numerous substances that human beings need. But they are toxic when taken in too large quantities. For the devoted anti-alcohol campaigners it came as quite a blow to learn that when up to 35 ml of alcohol is imbibed per day there is a definite positive effect on health!

As long as the fundamentals of the effects on the body, its cells or its subcellular components are not known, extrapolation of effects from the range of high dose to low dose will never be reliable.

Linear extrapolation is unjustified in the case of two types of regularly occuring phenomena. One type is the one just referred to: vitamin A and kitchen salt. The body needs small quantities for its vital processes and to extend life expectancy, but above a certain dose the benefits cease and the harmful effects begin. In the other type of phenomenon the negative effect occurs only if two or more molecules or quanta hit the target at virtually the same time. In such a case the negative effect simply vanishes below a certain level of exposure. (one hit has no effect).

The lesson I would like to draw from this is that we will not really understand what causes negative effects found phenomenologically in large samples exposed to high doses until further research is done into the basic properties of the toxic effects.

Secondly, I would like to make a brief comment on the risk formula:

Risk = Probability of accident x Consequences of accident

What if we approach the limit of zero times infinity? Some consequences are emotionally more serious than others. If we read that terrorists have murdered some poor fellows in a far-off country, we may experience a moment of uneasiness and compassion. But most of us would be more upset if the victims were women an children. I have the feeling that if a possible danger is related to our genes, we feel an exceptionally strong urge to eliminate the threat. Unfortunately, the danger associated with nuclear reactions has some relation to possible gene modification. If this is perceived by the population at large the opposition to the use of nuclear power may remain much stronger than a simple calculation of probability of occurance times casualities would warrant.

We are now in an era in which everybody seems to worry about everything science reveals - the 'Age of Anxiety', according to Weinberg. There is nothing more effective for increasing public anxiety than the treat of a good catastrophe, particularly towards the end of a millenium.

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