



**DISCUSSANT RESPONSE**

by

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to papers by

**Alvin Weinberg, Frederick Seitz, James Fleming, and Itamar Procaccia**

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Comments on the papers to be presented at ICUS, Seoul 1991

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This article includes comments on the following papers to be presented in the committee 1 "The Limits of Science":

Alvin M. Weinberg: Limits on Science for Policy and Policy for Science.

Frederick Seits: The Future of Science.

James R. Flemming: On Pathological Science.

Itamar Procaccia: Chaos as a Limitation on Predictability, Not on Science.

The comments are given in this order, and an opinion of myself is given at the end.

Comments on the paper by A.M. Weinberg

This author points out two limitations of science, the budget to basic research and the trans-scientific problems. I agree with this author's opinion in that these are the most important problems. Yet, I have a slightly different opinion.

We should discriminate two types of basic researches, a research without practical application but consuming a lot of money, i.e. a big science, and a pioneering work consuming very little money.

The former is affected much by the economical or even political situation, and we need only a few sites in the world to continue it. The

latter has a difficult factor because it is not easy to assure the success or the benefit of the project. Therefore, we need a clever decision of persons engaged in screening. Moreover, a sense of good basic research must be owned both by scientists and the regulators.

I think that the difficulty of the second type of limitation lies in the social situation, especially that of the mass education. The education of people who are not engaged in the science seems to be one of effective remedies.

#### Comments on the paper by F. Seits

This paper discusses on general attitudes of people or governments on scientific activities and lists up several factors to decline science. The author suggests necessity of social and political structure encouraging free enterprise with minimum control, but proposes no substantial plan for it. The author points out also active objectives to the science, and finally a serious problems is pointed out, i.e. the too much complexity of unsolved problems.

I would like to say that the decrease of interests in scientists and public people may be reduced to a certain degree by educational and social systems. Loss of interest is partly because of a hard work for catching up with frontier knowledges. However, better textbooks and guidances will encourage students and good documentary films will serve for strong motivation. What is important is that efforts to promote this line should be well awarded. In addition, we should assure good posts for young scientists engaged in these activities.

The last factor coming from complexity of phenomena and the limit of scientists' ability is the one which we should give up. We do not need to hesitate to stop the research and look for another mental activity.

#### Comments on papers by J.R. Flemming

In this interesting paper the author explains how pathological sciences become to be supported by scientists, societies and governments. The problems lie partly in individual scientists and partly in public people. The key point might be that scientists must not be isolated from other proper scientists, but should work independently so as to develop original ideas.

As for the illusion owned by massive people, I would add a factor, the education of science for general people. In the school education of science they learn mainly what are already established, but seldom learn how they are established or that even established knowledges are subject to criticism. Therefore, people are apt to accept or reject anything easily without proper criticism. By knowing how individual knowledge was established or by an experience to establish by themselves people will be able to criticize judgements done for technological problems.

#### Comments on the paper by I. Procaccia

This paper introduces a newly recognized concept "chaos" by the use of a simple example, and how the behavior of a dynamical system is unpredictable. He claims that the existence of chaos is by no means a limit of science. This claim is right and I agree with it in principle.

However, the statement "the problem which can not be answered is not concerned with physics." says too much. The problem which can not be answered is either difficult essentially or difficult only at the present

level of science. Note that the predictability is the most important and expected factor of the physics.

#### Summary of the above comments

The limits discussed in above papers seem to be classified roughly to two categories. One is the limit coming from lack of understanding or sympathy by general people or regurating persons. The other lie in the science itself.

Most problems belonging to the first s category are more or less solved through science education of students and grown-up people. I would like to remark that even students oriented to social or political sciences can show an interest in natural sciences and technologies, if they are introduced carefully. I give an example below.

I have a course of physics for students of social and political sciences. In this course I often tell the students as homeworks to make experiments or numerical simulations of relatively simple problems in order to have experiences of finding something by themselves. The examples of problems are to observe the forced oscillation or fluid flows, or to simulate the random walk, dynamical systems such as the logistic models, the form of macromolecules or the behavior of ferromagnetism, by the use of dyes (some students use a microcomputer). I expect them to enjoy observing these physical systems and to extract conclusions. I have a hope that integration of these experiences affects them to aquire proper attitude for scientific or techhnnological problems. This way of education can be applied to general people also.