DISCUSSANT RESPONSE

by

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to **Frederick Seitz's**

THE FUTURE OF SCIENCE

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THE FUTURE OF SCIENCE by FREDERICK SEITZ

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I. REVIEW

The two major influences of science on society are conceptual enlightenment and technical innovation. Understanding of natural phenomena has helped remove numerous mysteries and superstitions. Science has improved many traditional technologies and also generated entirely new technologies. In addition science holds its own aesthetic appeal for its practitioners. The geometric growth of science has greatly improved health, longevity, communication and travel. The question is whether science will continue to grow without limit.

Although predictions about the future are difficult because nature constantly springs new surprises, yet almost certainly science will continue to make spectacular advances. Scientific studies keep broadening in scope and grow remarkably more interdisciplinary. Thus there seems to be a limitless frontier.

Factors Favourable to the Continued Advance of Science

1) Innate curiosity: Curiosity about the natural world and a desire for self expression will continue to drive the evolution of science, building on the solid platform of the cumulative acquisitions of the past.

2) Practical need, national pride: Growth in scientific knowledge will be fuelled by a basic interest in the revelations of

science, by its educational value and by the need to improve existing technologies, particularly in the light of dwindling resources. National pride has been a strong motivating factor in scientific growth since the time of Galileo and this is likely to continue.

3) Global issues: Genuine global problems like the green-house effect, cancer, AIDS will require world-wide coordinated efforts to overcome them, much like the international cooperation for the exploration of the Antarctic.

Extension of Scientific Research

Even if we are agreed that continued progress in science is important and indispensable for our future, can we expect this to occur worldwide more or less automatically? The growth of science in any society depends upon the level of intellectual freedom and the availability of suitable institutions and resources. In well established centres of basic research, individuals from many cultures have made substantial and brilliant contributions.

However not all cultures provide equally good environments for truly creative research in science even when they possess the necessary infrastructure. Mainland China despite a long history of cultural and technical development, has never adequately integrated itself into the world scientific community. Recent developments in Taiwan will therefore be worth watching for comparison. Japan's current economic success is based largely on the use of borrowed technology and it is not contributing to basic science commensurate with its wealth and technical skills

probably because it is deliberately underplaying basic research as compared to matters of immediate practical consequence. India, before the rise of Islam, made major contributions to mathematical analysis and astronomy and could again do so if its current economic and social problems were resolved.

From 700 to 1400 AD, the Moslem world played an enormously important role in consolidating scientific knowledge from India to the Mediterranean, placing its own imprint on the fusion. Its scholarship also sparked off the Scientific Revolution in Europe. However the Mongol invasions of the thirteenth century, and the Industrial Revolution resulting in European expansionism threw the Moslem world off balance and it has found refuge in fundamentalism and rejected major involvement in world science ever since. The strong influence of religion on so many aspects of Moslem life may make impossible the uninhibited speculation that is so important for the development of science.

Factors that Could lead to the Decline of Science

1) Decline of interest: There could be a decline of interest in science amongst the most talented of our students, but this seems highly unlikely. Although some fields become less attractive as opportunities for new developments appear to be exhausted, fresh fields always emerge.

2) Public interest: As science becomes more sophisticated and specialized, communication between scientists and the public becomes increasingly difficult. Because of its impact on everyday

life, public interest is unlikely to die out, yet it is important to actively encourage this interest to ensure continued public support for scientific research.

3) Student interest: With changing social values, students in the USA have become less interested in science. A contributory factor has been the decline in the quality of school teachers, who have failed to motivate their students adequately. Fortunately this is not the case among children of recent Asian immigrants to the US, nor among students in Europe and Asia.

4) Cost of equipment: As instruments become more sophisticated they become more expensive and even a modest laboratory may cost several million dollars to set up. Increasing costs will force the development of alternative approaches. Human ingenuity will find other less expensive ways of doing experiments and this process may even lead to great advances. Budgetary limitations may not therefore pose absolute barriers to scientific progress. However research must continue to be funded and directed primarily by those familiar with the basic sciences. Some restrictions are however inevitable if the funds available are not to be spread so thinly as to be ineffective.

5) Upheaval: It would appear that only major violent global sociological or physical upheavals could affect scientific advance, although the focus of scientific attention may be determined by ongoing public concerns.

Effects of Anti Science Movements

Powerful orthodoxies have often arrested the development of science in the past. The heliocentric theory of Aristarchus was rejected as heretical. Given the turmoil of the early Christian world, if large portions of Greek science had not been preserved in the Islamic world, they would probably have been lost forever. Similarly, the Inquisition delayed the publication of Copernicus' treatise and forced Galileo to recant. More recently, suppression of science has been seen in the Soviet Union, where Gamow was arrested and exiled for lecturing about quantum mechanics, and the head of his institute was sent to Siberia. The rise of Lysenko whose suppression of Mendelian genetics was responsible for the death of Vavilov is another example. The spurious distinction between Aryan and Jewish science attempted by Hitler lead to a great decline in science in Germany. The Scopes trial in Tennessee, the Creationist movement in the US and opposition to anthropological research in racist South Africa are other such examples. The endorsement by the Soviet Academy of Sciences of the exile of Sakharov, the complete disruption of universities and research institutes in Mainland China during the Cultural Revolution and even the present attitude of this government towards its intellectuals raises doubts about the growth of science in a dictatorship.

Importance of an Open Society

The best guarantor of the progress of science is an open decentralized society which encourages free enterprise.

On many occasions, groups have arisen to oppose technological progress - the Luddite response. Sometimes these are groups whose interests are adversely affected by new developments. But in other cases the objectors seem bewildered by the pace of change and react as if science and technology are directed by evil forces. Peaceful uses of nuclear energy are often the target of modern Luddites.

Science must follow its own course in its quest for knowledge. The use to which this knowledge is put is governed by socio-political activity, by force of circumstances and by moral and ethical considerations. Human knowledge can be used for good or evil and in itself is morally neutral. Ethics impinges when actual use of this knowledge is contemplated and then decisions are in the hands of governments. No one can question support for cancer research, although there is every danger that this could be used to induce cancers. Similar considerations apply to defence related research. Charismatic leaders using empirical techniques have on many occasions induced groups to engage in highly destructive activity. Although a scientific understanding of such activity could be used to forestall dangerous movements, it could equally be used to strengthen the powers of an unscrupulous dictator. In all such cases the question is not of the morality of scientific knowledge but of the principles on which a society is based and its inbuilt checks against the misuse of power.

Trends in the United States

The growth of anti science movements in the US shows that the existence of an open society by itself is insufficient to ensure the growth of science. Such movements, popular even within intellectual and university communities, would prefer a more restrictive society in which scientific research is closely controlled. These groups don't seem to recognise that it is precisely developments in science that have enabled modern society to thrive and support a large intellectual community; and their activities, if successful, would revert us back to an age where life for most was poor, short and nasty.

Barriers Originating from Within Science

Even if interest in scientific research continues and adequate freedom and resources are made available, are there any inherent obstacles to its growth? One possibility is that increasing levels of complexity may make phenomena incapable of comprehension by human minds. This could occur for example in studies of the living cell or long-range predictions of the weather or of earthquakes. We would then be compelled to adopt new attitudes towards the understanding of such phenomena. A different barrier is the existence of phenomena which lie beyond the scope of the scientific method, as for example, the wherefor of our universe or the comprehension of the qualities of the human mind.

II. COMMENTS

Professor Seitz has presented his views on the future of science both clearly and cogently. His arguments are generally unexceptionable, but some points may not be universally accepted. For example, his observations on science in different cultures may have too western an orientation and participants in this seminar from these cultures may want to present their own viewpoints. Everyone may not also agree with his dismissal of all opponents of the use of nuclear energy as modern Luddites. Many highly regarded scientists are themselves not in complete agreement on the various pros and cons of this complex issue, and this is typical of many other such issues at the science-society interface.

It may also not be enough to say that human knowledge is value neutral and the question of ethics of the use of such knowledge is basically one of the inbuilt mechanisms in society against the misuse of power. Science has brought about profound changes in society and scientists have therefore a special responsibility even though decisions are ultimately taken by governments. An important question here is whether there should be self imposed restrictions on scientific research as for example was pleaded for by Weizenbaum in the context of computer science or the ongoing debate on aspects of genetic engineering. Whether such self imposed limits will be proof against the curiosity or the personal ambitions of individual scientists, or the collective mania for power of national governments, is of course moot.

Finally there is the question of whether unlimited growth of science is possible in a limited environment, even though the limits one is alluding to here are physical rather than intellectual.