Committee I
The Limits of Science?

DRAFT--5/15/91
For Conference Distribution Only

THE FUTURE OF SCIENCE

by

Frederick Seitz
Former President
The Rockefeller University
New York, New York, USA

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

C1 F.5

coded:futsci.1 (ICUS)

DRAFT 4/10/91

THE FUTURE OF SCIENCE

Frederick Seitz, The Rockefeller University

Let us attempt to look forward. As has been stated many times, the two major influences upon society emerging from the evolution of science are the effects on conceptual enlightenment and technical innovation. Both are equally important in their own ways. Science has shed a clear light of understanding on many aspects of the physical and biological world about us that were once deemed to be mysterious and potential objects for superstitious beliefs. On the technical side, it has provided radically new ways of improving classical technologies such as agriculture, medicine, mechanical engineering and metallurgy. Still further and at least as important, scientific research has made it possible to generate entirely new areas of technology such as those linked to post-Lavoisieran chemistry, electromagnetic devices, electronics, information processing and nuclear energy. All of these are essentially indispensable to modern life.

Beyond all of this, some aspects of science have their own intrinsic aesthetic appeal not unrelated to that of the arts, although usually appreciated principally by the dedicated professional workers.

For about five hundred years the attention and resources devoted to the pursuit and the application of science have increased almost geometrically with time at great profit to society, not least to those in the industrialized countries. Along with this, as has been mentioned above, have been great improvements in health and longevity as well as almost miraculous advances in such matters as communications and travel.

Granting all of this, one may, nevertheless ask about the future of science. Do we indeed face what has

C1 F.5

been termed an endless frontier and if so is it certain that scientific research and its application will be extended indefinitely?

It should be made clear at the start that one cannot hope to predict the course of discoveries in any given field of science in detail, even under the best circumstances. One of the most important characteristics of scientific research is the continuous emergence of surprises - the natural world has its own inner structure and is not beyond turning our expectations on their heads. No generation of scientist can really comprehend in any detailed way where the continued broad pursuit of science will lead. In this sense our own generation is not different from those which have gone before. Discoveries to be made in the next century may well eclipse all that has occurred up to the present and cause posterity to regard our status and outlook as somewhat primitive.

What is most apparent in the present stage of evolution of science, along with increasing degrees of specialization, is the ever-broadening scope of the segments of the natural world about us, both physical and biological, which become amenable to investigation by the methods of science. Associated with this is the remarkable way in which disciplines intersect one another increasingly in spite of greater specialization on the part of individual workers. Planetary studies become more deeply involved in geological and atmospheric science as well as basic chemistry and physics. Galactic astronomy leads into cosmology which in turn intersects with the developments of high energy particle physics. Geology, oceanology and atmospheric science become linked to studies of holistic earth dynamics rather than remaining descriptive studies of relatively static systems. Reductionist aspects of biology call upon highly sophisticated chemistry and require the use of complex physical instrumentation. Medical science finds that some of its most revolutionary advances borrow discoveries from the work of the cellular and molecular biologists. Some branches of mathematics find that they can advance most effectively only with the use of super-computers. Computer design, in turn, relies increasingly on advances in chemistry, physics, materials science and mathematical logic. The field of neurophysiology which is still in its infancy promises to develop cross links with complex aspects of the theory of information processing as well as cellular and molecular biology.

The vast extension of chemical knowledge that emerges from the field of biochemistry assures us that the aspects of science associated with the preparation and study of synthetic materials for their own sake or for practical use is still in its infancy. For all practical purposes there is in this area, as elsewhere, an essentially limitless frontier.

C/ F.S

FACTORS FAVORABLE FOR THE CONTINUED ADVANCE OF SCIENCE

1) Innate Curiosity

The most important positive factor assuring the continued advance of basic science lies in the combination of earnest curiosity regarding the natural world about us and the desire for self-expression that resides in many talented and imaginative young people - deeply ingrained human traits. These traits have been instrumental in the evolution of science from its beginning. Indeed, such curiosity concerning the world about us can continue unabated for a lifetime in the well-initiated, not least in the professional scientist, in spite of varying levels of creativity.

Alongside this we now possess, as a result of nearly five centuries of experience, knowledge of the combination of experiment, logical analysis, speculative theory and institutional structure needed to form a solid platform for the advance of science. Needless to say, none of these guarantee the appearance of that flash of inspired insight from a great mind that is occasionally necessary to introduce a major new evolutionary concept in some field. In this respect we will apparently always depend upon the arrival of the appropriate level of genius at the scene of activity during special periods in the development of a field. Fortunately, such arrivals at pregnant moments seem to attract the appropriately gifted sooner rather than later. One can only hope that this will continue to be the case indefinitely.

2) Practical Need; National Pride

Also on the positive side, it seems clear at present that under normal circumstances the advanced industrial societies will have a continuous need for the further infusion of new scientific knowledge for several good reasons. Some of the need will arise from a basic interest in the revelations of science, some from its educational value and some from such issues as the improvement of public health, industrial competitiveness, defense and what might be called replacement technology - such as finding substitutes for materials in dwindling supply.

Then too, there are matters of national pride which have been a significant motivating factor in the past and which will probably be significant as long as we have a diversity of ethnic and cultural groups on an international scale. It is not accidental that a sequence of national academies of science was created throughout Western Europe at the time of the creation of the Royal Society of London in 1660. It was modelled, in turn, on the Accademia dei Lincei, founded in Italy in 1603 at the time of Galileo.

3) Global Issues

Finally, it is not unlikely that there will be genuinely global problems that require the encouragement of reasonably coordinated basic as well as applied research from many centers on a world-wide basis. Issues such as concern regarding the global environment or matters related to health such as cancer and acquired immune deficiency syndrome (AIDS), not to mention as yet unforeseen but inevitable pandemics, will require enlisting the attention of scientists from many institutions who are prepared to work at the most basic levels of current understanding. It is, in fact, remarkable that the worldwide epidemic of AIDS occurs just at the time when the understanding and the instrumentation for detailed scientific investigations of the disease are possible and can be carried out internationally in a concerted way. This is undoubtedly not the last time that the international scientific community will be called upon in a similar way.

Then too, there will be scientific adventures which can benefit from international cooperation. The

C.1 F.5

coordinated research programs in the antarctic provide one present-day example. The development of very high resolution astronomical observatories with extended arrays on the moon which, for example, might observe planets on neighboring stars could be one for the near future.

EXTENSION OF SCIENTIFIC RESEARCH

If we grant that the continued advance of basic science is exceedingly important, indeed indispensable for the future of civilization, we may well ask whether or not such pursuit can be expected to occur more or less automatically on a worldwide basis much as it has through so much of Europe and North America. It should be emphasized that we refer here to the development of the basic rather than the applied sciences which are far easier to transfer from one culture to another.

C.I.A.S

The extension of research in basic science in any given society will depend, among other things, on the level of intellectual freedom, the availability of institutions which can form a base and provide a structure for a discussion and review of scientific issues. It will also require a minimal degree of wealth, the pursuit of some fields requiring more, others less.

It is interesting to note that within the ongoing centers in which basic research is thriving individuals from many other cultures and with a great variety of ethnic backgrounds have been able to make substantial, even brilliant, contributions. The important factors required are that the individual have a deep personal interest in science, a willingness to make a serious commitment, innate talent and the ability to pursue close communication in one way or another with those in the frontier sections of the field in which he or she decides to work. Those communities in which the scientific culture is deeply imbedded can and have served as hosts for individuals from many other societies when the requisite desire, interest and talents are available.

In spite of the fact that such individual talent is so broadly distributed around the globe it does not follow that all cultures provide equally good environments for the production of truly creative basic research even when the wealth and scholarly institutions associated with such cultures are in other ways remarkable. The path to the more nearly worldwide extension of sources of basic science may be slow if not actually difficult to achieve. Let us consider some examples.

Mainland China has not, at least to date, been able to become adequately integrated into the world scientific community in spite of the fact that it has a long history of outstanding cultural and technical development. This fact transcends the circumstance that it currently has a government that is an oppressive dictatorship which views its intellectual community with suspicion. There have been long periods in the history of Chinese culture in which the situation was otherwise. It will be interesting to observe the developments which take place in Taiwan in the period ahead since it is encouraging the advance of science on a broad scale with the means available to it.

Japan provides another interesting case. Although its current economic success is based to a major extent on the acquisition and use of borrowed science-based technology, it cannot be said to be making comparable contributions to basic science commensurate with its wealth and technical skills. One suspects that the government has chosen to institute policies which do not encourage the pursuit of basic science in the special way found in most European countries. Its policies place maximum emphasis on matters of immediate practical consequence. Such policies could, of course, be modified but it would, at a minimum, require a broad reexamination of the framework within which the scholarly community, not least the scientific community is supported.

In its early history, and in fact well before the rise of Islam, India was a major contributor to the advancement of science through creative work in mathematics (analysis) and astronomy. One suspects that it could readily become a major contributor again if its current economic and social problems were resolved. Indian scientists like their Chinese counterparts have performed brilliantly when the cultural environment is appropriate.

Finally, let us consider the Moslem world which once extended from the Atlantic and well into Asia. During its peak centuries, say between 700 A.D. and 1400 A.D., it played an enormously important role in consolidating the scientific knowledge of the known world ranging from

India to the Mediterranean, placing its own remarkable imprint upon the fusion. Moreover, Moslem scholars through cultural transfer sparked the Scientific Revolution which emerged in Europe in the late Middle Ages and Renaissance and which is associated with the work of such great figures as Copernicus, Galileo, Kepler and ultimately Newton.

Islam suffered two great reverses in its political and cultural history. First was the devastation resulting from the Mongol invasions in Asia and the Near East, including Persia and Mesopotamia, in the thirteenth century. In this event the Mongols destroyed rich communities, leaving behind pyramids of the skulls of the inhabitants. Second, the rapid development of technology in Europe in the following centuries, when coupled with the expansionist period that went with it, threw the Moslem world greatly off balance. Its outlook was radically changed from one of enthusiastic selfconfidence and openness to a state of defensive retraction. In this situation, the Moslem world has, to a large extent, found refuge in forms of fundamentalist thinking which were a part of its initial strength. In brief, the greater part of the Moslem community has, at least for the present, rejected major involvement in world science even though its own role in the evolution of science has been a most remarkable one. Recent events in Iran in which Khomeini and his followers essentially obliterated the attempts at introducing "Western" concepts and institutions, including science, by the Pahlavi government are more than symbolic of the current state of affairs.

In truth, the strong influence of religious doctrine in so many aspects of Moslem life may indeed provide a formidable obstacle to the type of uninhibited speculation which has been so important for the development of modern science. It is perhaps notable that, in spite of its many outstanding merits and the presence of brilliant scholars, Islamic science did not encourage the type of free reign of thought that allowed individuals such as Copernicus and Galileo to emerge.

FACTORS THAT COULD LEAD TO THE DECLINE OF SCIENCE

There clearly are a number of factors that could lead to the decline of science. Fortunately most, although not all, are probably limited in scope and effect when viewed from a world-wide perspective.

1) Decline of Interest

The most obvious is a possible decline of interest on the part of those with the greatest talents. This seems unlikely if we view the broad challenges offered across the frontier of science. One can imagine that some fields such as classical nuclear physics or even high energy particle physics eventually could become less attractive to the most brilliant and creative individuals as the opportunities for new developments or applications appear to be exhausted. Actually a decline in interest in high energy physics seems indeed to be relatively far off, when viewed from the present, as long as the basic theory surrounding high energy particle physics remains far from complete and there is such a strong link between that field and cosmology.

Similarly, the challenges offered by the life sciences seem to be essentially unlimited at the present time, particularly if we consider our still primitive understanding of cellular mechanisms, including the very important matter of cellular specialization, as well as the intricacies of the nervous system. Then too we have only the most rudimentary understanding of the interrelation of the holistic and the molecular properties in even relatively simple biological systems - a topic which was once deemed central to the subject, but is now almost ignored by "main line' biologists.

2) <u>Public Interest</u>

It is evident that communication between the creative scientists and the general public is becoming more and more difficult as science advances in sophistication and becomes more specialized. While this may well weaken the everyday interest of the average person in the deeper aspects of science, there undoubtedly will be a continuous and widespread interest in the practical fruits of science to the extent that they have an effect on everyday life. In spite of this it is very important that those interested in encouraging the continued public support of the most basic frontier aspects of science develop and use whatever means and talents they have to retain public interest since it will inevitably have an influence on the magnitude of such support.

C1.A.5

3) Student Interest

It is well-known that the interest in fields of science of second and third generation students has dwindled in United States - somewhat reminiscent of the way in which interest in professional engineering dwindled in the United Kingdom in an earlier generation. This is a sociological matter of complex origin stemming, among other things, from a shifting sense of social values - that is, what is important in life for the individual. Doubtless one of the factors causing the decline is the decrease in the quality of the members of the teaching profession at the primary and secondary levels and their inability to strike the cords of inspiration in the students. Fortunately for the United States, the interest in science has not diminished among the children of recent immigrants, particularly those from Asia, who seem to have their own sources of inspiration. Moreover, the interest in science in continental Europe and the industrialized Asian countries appears to be maintained at least on a continuing level.

4) Cost of Equipment

It is hardly necessary to mention that the cost of equipment and related support for research in some of the most interesting areas of science has become increasingly high as the problems have become more and more intricate. As commented earlier, there are even branches of present day mathematics which rely upon the use of the most advanced and expensive computers. Biological research has long since passed far beyond the string and sealing wax stage. Several million dollars is needed to equip even a modest biochemical laboratory for frontier research.

It is not inconceivable that the pursuit of some areas of experimental physical science, such as high energy physics, will eventually require quite different approaches from those used at present. In fact, it is reasonable to suppose that the superconducting super collider (SSC) now being planned for the State of Texas will represent the last in the evolving generation of particle accelerators which started some sixty years ago with the development of accelerators such as the cyclotron.

One should not, however, underestimate the ingenuity of the imaginative scientist in finding less expensive, although perhaps more time-consuming, ways of achieving challenging goals. In some cases such ingenuity even leads to great advances. While astronomers still use large mirrors for their research, ingeniously designed phased arrays of receivers are providing valuable astronomical information that would otherwise involve costs that would be either grossly exorbitant or completely beyond reach. Similarly, it is quite possible that space platforms and space vehicles which will be developed for other reasons in the future will provide the means for research in areas of science which would otherwise become too expensive to pursue for their own sake. Cosmic ray research carried out beyond the atmosphere may become central to high energy physics in the future.

It seems unlikely that limitations placed upon the budgets for science will impede its progress in any absolute way as long as inspired and imaginative scientists remain active, even though the approaches to some areas of investigation may require different methods of attack. What is important for the continuation of progress is to make certain that some more or less well-defined fraction of the wealth of the industrialized countries continues to go to the support of relatively free research and that the guidance of expenditures be determined primarily by those familiar with basic sciences.

CIA.5

As an aside, it seems reasonable to assume that the fraction of national wealth which one can expect to be devoted to the most basic, relatively unrestricted form of research is somewhere near its maximum at present in most industrialized countries in the Atlantic area, granting that the fraction can be expected to vary somewhat from time to time and from country to country depending upon circumstances. This assumption carries with it the implication that there will inevitably be something in the nature of a limitation to the opportunities in areas of frontier research for those entering the scientific profession if the available funds are not to be made relatively ineffective by being spread too thinly. Such a limitation will be much less severe in areas of applied research and development.

5) Upheaval

In summary, it would appear that only some major violent sociological or physical upheaval of an

C1.G.S

essentially global nature could change the general advance of science, granting that the areas to which major attention is directed at any given time may vary as a result of fashion, economics or urgent public request based on some issue of real or perceived importance for the well-being of society. For example, public concern with respect to acquired immune deficiency syndrome (AIDS) or access to new energy sources have had an influence upon public expenditures from time to time.

EFFECTS OF ANTI-SCIENCE MOVEMENTS

If we look back upon the history of science, we recognize that there have been instances in which the course of science was arrested or even suppressed as a result of social pressure associated with the emergence of a powerful orthodoxy. Aristarchus' proposal of a solar-centered planetary system was rejected as unorthodox or even heretical at a critical moment in the

CI.G.5

evolution of Greek science. Indeed, were it not for the fact that large portions of Greek science found an enthusiastic reception in the Islamic world and became imbedded in its culture as an active ingredient, the foundations generated by the Greeks might well have been buried in the ruins of antiquity. Turmoil in the early Christian world, as it sought consolidation, might have proved fatal to the resumption of an interest in science.

Then too, in more recent times the Inquisition attempted to arrest the advance of science as part of its program to suppress the Reformation and other "heresies". Fear of its authority and power were sufficient to delay the publication of Copernicus' great treatise, just as it was sufficient to cause Galileo to deny publicly the truth of his firmly held beliefs. In still more recent times, we have had several incidents in the Soviet Union, hopefully now on a different track, in which well-established areas of good science were suppressed. Among other instances was the arrest and exile from Moscow to Georgia of George Gamow in the late 1920's for lecturing openly in Moscow on the newest developments of quantum mechanics. The head of the institute at which he lectured was sent to Siberia. There is also the authority bestowed upon Lysenko in the 1930's which enabled him to suppress work in the field of Mendelian genetics and which led to the premature death of Nikolai Vavilov.

Alongside this was the spurious distinction between so-called Jewish and Aryan science that was built into a brutal and fiercely destructive doctrine by the National Socialist regime in Germany. It led to a great decline in science there for a long period of time.

The Scopes Trial in Tennessee and the impediment of anthropological research in South Africa during the period of Apartheid are peripheral and fortunately limited examples of threats to the natural evolution of science. Whatever else it may be, the Creationist movement in United States must be regarded as a continuing, if minor, threat to the pursuit of science.

Had the Soviet Union ever achieved the type of world hegemony that was pursued by Gorbachev's predecessors, one might wonder if its leadership would have continued to pursue scientific research with enthusiasm. The fact that the Soviet academy of sciences could be placed in a position where its membership felt it necessary to endorse the demotion and exile of Sakharov to Gorky says a great deal about the previous leadership's attitude toward science and the scientist. The uncompromising attitude of the present government in mainland China toward its intellectuals speaks volumes about the fragility of science in that country. Those who saw the shambles to which university and other basic research institutes in mainland China had been reduced as a result of the Cultural Revolution can have no illusions

C1 F.5

concerning the stability of science policy in a dictatorship.

IMPORTANCE OF AN OPEN SOCIETY

All of this reaffirms what has been said many times previously: The best guarantor of the advance of science is a social and political structure which places a high premium on openness, the encouragement of free enterprise and minimizes centralized control of society to the extent feasible, granting that the government must retain sufficient authority to promote the health, freedom and prosperity of its citizens.

VIRTUE AND EVIL IN SCIENCE AND TECHNOLOGY

As has been mentioned earlier, there have been various times in human affairs in which individuals or groups have risen up to propose a halt to technical progress - the so-called Luddite response. In recent times the objection has been extended to almost any area of science that might lead to new technology.

In some cases the proposals are well meaning in the sense that they are intended to come to the aid of a special group that is being disadvantaged by new technical trends. The political actions taken in some regions in United States which have many small dairy farms against the use of milk-producing hormones provides an example of this.

In other cases, many of the objectors seem to have much broader and diffuse complaints, being perhaps personally bewildered by the pace of change and desiring a complete restructuring of society - as if science and technology were directed in some way by forces of evil intent.

Fields of investigation such as those focusing on peaceful and safe uses of nuclear energy are frequently attacked broadside these days by the modern Luddites.

C1 F.5

In fact, in the decade after World War II and in the wake of Robert Oppenheimer's declaration that the physicists "had known sin", some biologists tended to frown upon those involved in the physical sciences as if their own activities were so obviously humanitarian in spirit as to be utterly beyond objection. The opponents, however, have since disillusioned them by attacking aspects of recombinant DNA research, a natural outgrowth of brilliant advances in cell biology and biochemistry.

Science must follow its own channels, adding to our store of available knowledge and understanding. The use to which society places this knowledge represents activity at an entirely different, more socio-political, level in which circumstances, as well as ethical and moral considerations, enter the picture.

The disease cancer is universally regarded as an evil. No reasonable individual would question research which seeks to discover the factors either inherent in organisms or in the environment which can lead to cancer even though under certain circumstances that knowledge could be used or misused to induce cancer that would not otherwise occur. One may reasonably ask whether it is really different for a scientist to investigate the potentialities of a new discovery for use as an offensive or defensive weapon primarily with the intention of gaining such knowledge for its possible use in defense.

Ever since mankind developed tools, learned to control the use of fire and began the domestication of animals and plants the framework of knowledge which our species has developed could be put to a variety of uses which might, in appropriate situations, be regarded as either good or evil. Knowledge of the inherent capabilities of our discoveries or inventions is morally neutral. Ethical issues emerge at the point at which actual use is contemplated. And here the matter may become highly controversial. One is reminded of

C/A.S

President Truman's response to the issue of sin after a discussion with Robert Oppenheimer: "He thinks he ordered the use of the bomb."

Let us conclude this theme by raising an admittedly hypothetical and complex issue which the scientific community could eventually face if our understanding of human psychology advances sufficiently - an open issue in itself.

The past century, and indeed many earlier centuries, have been characterized by situations in which charismatic leaders, using what are clearly grossly empirical techniques in an intuitive way, have succeeded in inducing otherwise decent individuals to engage in activities which have turned out to be highly destructive to others, or to themselves, or both. In most such cases the initial intent of such movements may have seemed rationally and even ethically justifiable. However, they clearly can take on a life of their own in a way reminiscent of the development of a cancer and become highly destructive.

The question arises: would it or would it not be morally appropriate to attempt to understand this aspect of human behavior at the deepest possible level of scientific investigation? Assuming success, the knowledge clearly would constitute a double edged sword. In the best conditions it could, in principle, be used to forestall dangerous political and social movements, in the worst, it could strengthen the powers of an unscrupulous dictator.

It would appear that the basic issue here, as in many other cases, has much less to do with the question of the morality of scientific knowledge than it does with the principles upon which a given society is based and in particular the safeguards it adopts to forestall dangerous excursions linked to the misuse of power.

C/G.S

TRENDS IN UNITED STATES

A segment of the anti-science movement in United States deserves special mention since it shows that an abundance of freedom in a society may not alone guarantee the unhindered advancement of science. Quite apart from the Creationist movement mentioned earlier, we see, particularly in the United States, the rise of what could readily become an anti-science movement within substantial portions of what is called the intellectual community, not least the university linked community. At its worst this movement is driven by groups of individuals who have enjoyed the benefits of education and would seem to prefer a much more restrictive society in which there are far more centralized controls and in which further technological advance is either brought entirely to a halt or is subject to very great limitations. Such groups tend to be well-funded from both public and private sources and to receive a proportionately large amount of favorable attention from the media. Scientific research, as one of the principal sources of new technology, should, in the view of such groups, be placed under closely regulated and not as yet well-defined controls. A significant portion of the attacks on research in the field of recombinant DNA mentioned earlier are linked to this anti-science movement. In effect it joins forces in its own way with the Luddites.

What is most disturbingly contradictory about this trend is that imbedded in it is the failure to recognize that it is precisely the wealth and the advances in technology that have been gained through the free workings of science in the past few centuries that have enabled the intellectual institutions in United States (and incidentally elsewhere) to thrive and support a relatively large fraction of the population in intellectual pursuits. It is paradoxical that the

C1.A.5

activities of such anti-science groups, if successful, would ultimately undermine the very economic and social structure which supports them. One can only imagine that in some way the activists feel that they would be immune personally from the burdens that were experienced by humanity in the pre-scientific age in which life for most individuals was poor, short and nasty.

BARRIERS ORIGINATING FROM WITHIN SCIENCE

In conclusion, let us, for the sake of discussion, assume that an interest in the pursuit of scientific research continues and that reasonable freedom and resources are made available for it. What then can be said about obstacles that might arise out of the natural course of evolution of science itself. We shall leave aside issues related to the increasing cost of experimental equipment in some areas of science, such as high energy physics mentioned earlier.

There are two possible obstacles that deserve mention. First it is possible that advances in a given area may eventually encounter levels of complexity that are beyond our capacity to deal with in any direct way. For example we may face issues which are beyond treatment, even statistically, on the basis of knowledge gained from reductionist analysis - the tool which has been so powerfully useful since the dawn of science. We may never be able to use all the information being accumulated by molecular biologists to understand the workings of a living cell in a detailed, or even qualitative, manner. Accurate long-range predictions of the weather or of earthquakes may turn out to be hopelessly complex. If, or perhaps when, this occurs, we may be compelled to adopt new attitudes toward the process of gaining understanding of nature with a clear appreciation of our limitations, whether for human or more cosmic reasons.

Second, we undoubtedly will also face utterly imponderable issues which are entirely beyond our comprehension let alone our ability to treat qualitatively. For example, can we ever even begin to understand through the methods of science the wherefor of our universe with its intricate structure even though we may trace its origin back to an initial cosmic explosion. Will we ever comprehend the qualities of the human mind both in depth and in totality beyond knowing the details of its molecular structure and the simpler forms of molecular interaction.

Such issues remain open.