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Scientists and Society: Needs and Responsibilities

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In this lecture I shall first comment on scientists in modern society and then focus on some areas of stress between scientists and society where lay mutual responsibilities and needs. I shall conclude by emphasizing the need for mutual accommodation, common action, and continuous dialogue.

The recent advancement of science has been spectacular and the scientific frontier potentially endless. Similarly profound has been the impact of modern science on society and on man himself. And yet, the universal acceptance of science by society is still limited and in need of a more effective transmission of the intellectual and cultural value of science, and a meaningful discussion of the fears and suspicions of science by society. A large fraction of society looks at science with fear and suspicion and views a science-dominated world as unbalanced and full of pain and peril rather than full with opportunity, hope, and new freedoms.

1. Scientists and modern society

The crucial element of science has been and still is the scientist. Who is he? I attempted to answer this question in a book I published in 2001.¹ I noted, then, that today neither is science as distinct a term as it once was, nor is there distinctiveness in the term scientist. The proliferation in the numbers of those working in science today, the expansion of the scientific endeavor, the vast uses and applications of scientific knowledge have resulted in more than one scientific identity. Today, the term scientist embraces many and diverse people with broad and heterogeneous areas of expertise, interests, and attitudes. There are in science today many science workers and relatively few scientists, and while both are indispensable elements of science, the heart of science is the scientist.

Historically, scientists formed a community with no boundaries, where, in principle, everyone is free to enter, to work, to express his/her views, to be heard and to be contradicted. They adhered to the values inherent in the practice of science. Their community has been rather stable and largely incorruptible, sustained by a sense of dignity for its members by virtue of their exploring the truth. The scientific community itself has been largely shielded from social and metaphysical controversy by its limited impact on society, especially on man, and by metaphysical neutrality. Today, this is so no

more. Hence the question: Will the scientific society continue its stability and adherence to its tradition and norms so necessary for the benefit of both science and society?

I shall not attempt to answer this question, but rather I shall focus on a few areas of stress between science and society where lay mutual responsibilities and needs.

2. Areas of stress/conflict and scientific responsibility²

(i) *The “limitless power” of the method of science.* The ability of science to answer questions which can be defined scientifically seems limitless.¹ *The impression that there is no limit to what science can do represents an area of stress and potential conflict between science and society.* For there are limits even within the borders of science.

Systematically, modern science has reduced the physical world to molecules, atoms, nuclei and their constituents and on the basis of this knowledge at the most fundamental level succeeded in establishing the order of the physical world, based on the validity of the physical law. In this “reductionistic” approach, physical science laid the ground for a unified description of the physical world at the microscopic and, by extension, at the macroscopic scale. The recognition of the limits of this extension – that is, the recognition of the fundamental interconnections between the properties of the nuclei, the atoms, and the molecules on the one hand and the various forms of matter, the world as a unified whole, and in particular life on the other hand – is most significant. This is because the analysis of the physical world to its elemental constituents and the discovery of the fundamental laws that describe their behavior at the extreme reduced level, does not lead to its reconstruction on the basis of *only* this knowledge. It is hindered, for instance, by the enormous differences in scale and complexity. The whole is manifested in the particular and yet it has properties of its own^{3,4,5}. A number of scientists have stressed the need to consider holistic properties and teleology issues and have pointed out that neither it is possible to comprehend the basic phenomena of life on the basis of the known laws of physics, nor it is possible to understand man only by a reductionist’s view of him. The preponderance of scientists, however, uphold the view that all “*explanatory arrows point downward*”⁶, to use Steve Weinberg’s phraseology, that is, from society to molecules to particles. *But a reductionist view of man is in conflict with the world-view of a large fraction of society.*

And there are still other limits at the boundaries of science. There are, for instance, questions which although defined scientifically, have no scientific answer when formulated because they lie outside the province of science when they are posed and possibly they will be so for ever. Questions such as: “What is the origin of the cosmos?”; “What caused the big bang?”; “What is the origin of life?”; “How did the first organism emerge from inorganic matter?” These and other similar questions, science can ask, but it has no definite answer. As scientists we can express opinions about such questions, but we have no scientific answers. Questions of this nature show that although the borders of scientific knowledge are continuously expanding, some basic questions remain; they belong to the

area of “trans-science”.^{1,7} *It is the responsibility of the scientist to avoid claiming that we have scientific answers to such questions.*

(ii) The real or perceived adverse impact of science on traditional values; fears that the scientific view diminishes man. Values lay deep in humanity’s multiple cultures, traditions and religions. Traditional values – such as respect for life, liberty and justice; commitment to peace, freedom, and human dignity; reciprocity – guide human behaviour and constitute frames of reference for value judgment.

Science *per se* does not deal with values. Science, however, is not free of values in the execution of scientific research and in the application of scientific knowledge. There are values *in* science and there are values *of* science. The search for truth in science imposes on the researcher a moral conduct, which is not unlike the moral conduct of a person in the broader society, but it goes further. Science confronts the work of a scientist with the work of his colleagues and cannot survive without justice, honour and respect among them. Science, furthermore, is based on the free communication among scientists and on mutual trust. Freedom of thought and speech, justice, dignity, self-respect, and tolerance of differing views are all values recognized in the past – long before modern science – as necessary for the survival of society. On these very values science relies for its functioning, because scientific research is conducted by and for people, because science is a human activity. Thus, while the scientific picture of the world changes continuously, the values on which science and scientific behaviour are based remain fundamentally the same: universal, timeless values.

There are as well, the values of science, which characterize its functioning: rationality, verification of knowledge, discovery and correction of error, respect and acceptance of the proven fact, unification and coherence of scientific knowledge, cooperation, humanism. Humanism is a uniquely multidimensional value of science; as I said elsewhere, “If deep in the essence of civilization lies the emancipation of humanity, society cannot be truly civilized without science.”^{1,5} These values of science need to be broadly appreciated and to be recognized as complementary to the traditional human values. This recognition and this complementarity are necessary to moderate the image of science and modern scientist as antagonistic to accepted beliefs, norms, and values, and as increasingly questioning the traditional foundation of Western Civilization. *The degree to which the scientists and society are successful in this endeavour will enhance or limit the broader acceptance of science by, and for the benefit of, society.*

The scientist is, furthermore, faced with the deep-rooted fear of society that the scientific view of life diminishes man. To the Greek philosopher Protagoras, “*man is the measure of all things*” and to Aristotle, “*man is the ultimate supreme creation in the cosmos*”, while to Christianity, “*man is the image of God*.” Today, many fear that science is making this traditional, Western-Civilization-View, of man obsolete. Many across society warn that “society (is) dehumanizing rapidly”⁷ and others claim that we are heading for “scientific control of society”.⁸ Independently of the validity of these claims,

the view from science, as presented by most scientists, clashes with the view upheld by a large fraction of society that man is the supreme value par excellence,

And one can go even further, the fear of many in society of the possible effects on man of the recent scientific developments in biomedical sciences. They point to the ethics of human genetic engineering and to the possibility of inheritable genetic modifications in humans and thus they fear that humans are to be turned into and be bred like animals, hence signalling the end of man.⁸

Clearly, the perception that the scientific view of man is negative and that science destroys the fundamental image of man upheld by civilization, presents problems for those who argue that science is part of culture and should be integrated into the whole of civilization. This is one of the reasons why scientific literacy of society is of such importance.

(iii) Issues beyond the province of science. Science is not the only way to the truth, and to claim otherwise, as some scientists do, is a distortion of science leading to conflict. There are other, complementary, ways to the truth such as those of philosophy and religion. Science deals with questions that can be defined scientifically, can be studied by its method, and have a chance to be answered by its method. And scientists should demand respect by society of the proven scientific facts. However, science deals with neither ethical judgments nor with the ultimate meaning of life. There are neither ontological experiments in science nor laws which describe our love and respect for each other. These lay outside the province of science.

Beyond science, beyond the physical and the biological, beyond that which can be proved by the method of science and can be measured by the scientific instruments, lay the spiritual, the cultural, the intellectual traditions, the values of man, and the teleological concepts of philosophy and religion of which science does not speak. *To dismiss these “non-physical” aspects of human reality because they are not “proved” by the method of science, or to abandon science’s metaphysical neutrality and transform science to a myth, limits the universal acceptance of science by society and presents the scientist antagonistic to traditional world-views.*

Once the metaphysical neutrality of science is abandoned, science will be judged differently and will face new problems which, undoubtedly *will place science and the scientist in yet deeper confrontational posture and limit their societal acceptance.*

(iv) Perception of science as power to suppress and to destruct and the scientists as the instrument for negative uses of scientific knowledge. Increasingly, more people in society point to the dark side of the applications of science and picture science as a source of dangerous knowledge, which is used for destruction and limitation of man’s freedom, privacy, and safety. “The frightening thing which we did learn during the course of the war (WWII)”, said I. Rabi, “was how easy it is to kill people when you turn your mind to it. When you turn the resources of modern science to the problem of killing people, you realize how vulnerable they really are.”⁹ Science is thus looked upon as having set loose

against society unimaginable forces capable of causing widespread destruction and suffering, be it through nuclear weapons, chemical agents, or biomaterials. Look, they say, at the dimensions of the nuclear arsenals today (Table 1). Today, the nine nuclear powers have collectively over 20,000 nuclear warheads ready for immediate deployment; each of the thermonuclear bombs in these arsenals has a typical explosive power of several megatons. And they go further, they point out that the cataclysmic consequences of these weapons are with us because science and the scientists made it so. Because, since WWII, the frontiers of science and technology have become the frontiers of weaponry. Many of these weapons, including nuclear weapons, have been recommended, invented, developed and perfected by scientists.

Nuclear war, dear colleagues, is the most dangerous threat to life and the environment.

The fear that science is increasingly becoming a power for suppression and destruction and the perception of scientists as instruments of war diminishes their positive image and clouds their benevolent arguments.

Table 1: The nuclear arsenal today of the 9 countries known to have nuclear weapons.*

Country	Date of first explosion	Estimated number of warheads
USA	1945	5.400
Russia	1949 (USSR)	14.000
U.K.	1952	185
France	1960	<350
China	1964	<160
India	1974	100-140
Israel	1979?	100-200
Pakistan	1998	60
North Korea	2006	0-10

*Based on figures given by R. S. Norris and colleagues in a number of articles in the Bulletin of Atomic Scientists.¹⁰

(v) *The careless scientist; scientists beyond the borders of science.* Scientists often step over the scientific norms and become antagonistic in matters not scientific.¹¹ They speak on behalf of science on non-scientific matters or even on trans-scientific questions, spreading criticism, for instance, to the realm of belief, based not on what science says but rather on personal philosophy and personal world view.¹¹ Geneticists tell us that they have discovered “The Language of God,” theoretical physicists that they have discovered “The God Particle,” astrophysicists that they have discovered “The Mind of God” and that their theory now says God does not exist (“God is unnecessary”), evolutionary biologists that they have discovered “The Selfish Gene” and the “God Gene” and still others that they have discovered the “Theory of Everything”, and so on. Such expressions, even if they are not taken seriously, give the erroneous impression that science is omnipotent.

It is exceedingly uncomfortable to see scientists deal with God *scientifically!* *What an abandonment of the scientific tradition!* To deify scientific theories is to turn science into a myth and

expose science to undue criticism. Many in society are genuinely concerned that science is being turned into scientism and scientists into the High Priests of a new world view aiming to replace traditional world-views.

We must go back to our scientific tradition, which teaches modesty and instructs us to confine ourselves to questions which science can answer. We must observe the proper boundaries of science.

And we must distinguish when we are doing science and when we are extrapolating from it, *especially when we are teaching students.*

Equally discomforting is the fact that scientists frequently abdicate their responsibility to the norms of science in favour of national and commercial interests. As the percentage of scientists who work for governments and industries increases, problems of freedom of inquiry and communication increase.

Even more troubling are the increased incidents of fraud in science, as the recent cases in biomedical science can attest, whether these happened in South Korea or at premier USA Universities (Yale, Columbia, Harvard, Berkeley).¹²

And there is still much to be desired, in answering the cynical criticism levelled against us, namely, that “In the end, most scientists will do whatever there is money for doing.”

There is, thus, a need to uphold the scientific tradition of an open-mind, modesty, honesty and tolerance and to improve our image.

The diminution of respect for and trust of the scientist by society limits the acceptance of science by society.

3. Responsibilities and needs of scientists

- The scientist's foremost responsibility is to the scientific truth and to the integrity of science.
 - The scientist should uphold the scientific tradition and adhere to the norms of science.
 - The scientist has a fundamental responsibility to value and dignify life.
 - The scientists need to address the fears of society with modesty and to be ethically sensitive in addressing the ethical dilemmas deriving from the impact of scientific knowledge on man and his values.
 - The scientists must reassess their involvement with the machinery of war.
 - It is the scientist's responsibility to keep science open and transparent.
 - The metaphysical neutrality of science needs to be preserved.
 - The trust of society in science and the scientist must be safeguarded and indeed it must be enhanced.
- The most effective way for achieving this is by the responsibility of the *individual scientist and the scientific community.*
- The scientific culture and the humanism inherent in science must be transmitted more effectively to society, especially the young.

4. Responsibilities and needs of society

At the beginning of my presentation, I have indicated that the universal acceptance of science by society is still limited. A good fraction of society fears the impact of science on man and the environment and many in society believe that science sets its own conditions and imposes its own values on society. Clearly, modern society fails to fully appreciate what science is providing for it, in spite of the benefits it derives from science and in spite of the fact that modern society will cease functioning without science and science-based technology (technoscience). All too often society takes the benefits of scientific discovery for granted and all too often it exaggerates out of fear or ignorance the potential impact and the risks of new scientific knowledge. *Society, therefore, needs to accommodate science's unique ways of functioning and adjust to new scientific discovery, fully cognizant of the fact that scientific knowledge comes with benefits, but also with peril and pain.*

Repeatedly in the recent past the relationship between the scientists and society has been strained by several important issues — embryonic stem cell research and climate change to name just two. In such instances, society is not just sensitive to what science does or does not do, but oftentimes society overreacts casting aside long-range benefits. The recent reaction regarding scientific data used to evaluate climate change make the point.¹² *An important aspect of the scientific literacy of society then should be enhancement in society's ability to recognize that while even in science errors are made, inherent in the method of science is the capability to discover and to correct such errors.*

Only in a free and open society can the integrity of science be maintained, and a free and open society is foremost society's responsibility.

5. Together for the benefit of humanity

Scientists and society must work together to:

- Make science truly universal so that every nation can participate in, and profit from, science.
- Achieve mutual understanding and accommodation.
- Develop curricula to broaden the scientist's education in ethics and social issues, and to increase society's scientific literacy.
- Address the role of science in our common future and our common problems, such as those of war and peace, climate change, wide-spread poverty, energy and resources.
- Enter into a continuous, open, and meaningful dialogue based on mutual trust.

6. Science: endless frontier and prerequisite of hope

In closing, I wish to make one point perfectly clear, namely, that the attention drawn to the problem areas between science and society I have mentioned, is largely intended to stress the need for a better

mutual understanding, and the necessity to communicate better the values, culture, and content of science to society, *especially the young*. The history of the ways science progresses and evolves, and the unique past accomplishments of science - intellectual and utilitarian - constitute humanity's common heritage and unite humanity. Science remains an endless frontier full of excitement and adventure.

The knowledge which science will provide for society in the future, and the enlightenment with which society will use it, are the fundamental prerequisites for a hopeful common future.

Thank you.

6. References and notes

¹ L. G. Christophorou, *Place of Science in a World of Values and Facts*, Kluwer Academic/Plenum Publishers, New York, 2001.

² See, also, Loucas G. Christophorou, Invited lecture at the International Council for Science (ICSU) European members annual meeting, 29-30 September 2009, Podgorica, Montenegro.
http://www.academyofathens.gr/Documents/christophorou/Universality_of_Science_Limits_and_Needs.pdf

³ Paul Davies, *The Cosmic Blueprint*, Templeton Foundation Press, Pennsylvania, 1988.

⁴ Stuart A. Kaufman, *Reinventing the Sacred*, Basic Books, New York, 2008.

⁵ Λουκάς Γ. Χριστοφόρου, *Βήματα στην Επιστήμη και τη Ζωή*, Σύλλογος προς Διάδοσιν Ωφελίμων Βιβλίων, Αθήνα, 2009.

⁶ Stephen Weinberg, quoted in Stuart A. Kauffman, *Reinventing the Sacred*, Basic Books, New York, 2008, p. ix.

⁷ A. M. Weinberg, *Minerva* **10**, April 1972, p. 209; *Science* **177**, 21 July 1972, p. 211.

⁸ See, for instance, Havel, V., *The Need for Transcendence in the Postmodern World*, Speech in Independence Hall, Philadelphia, July 4, 1994; C. S. Lewis, *The Abolition of Man*, HarperSanFrancisco, 2001 edition; L. R. Kass, *Life, Liberty and the Defence of Dignity – The Challenge for Bioethics*, Encounter Books, San Francisco, 2002; R. S. Morison, p. 53 in [Chal8 .)

⁹ I. I. Rabi, *Science: The Center of Culture*, The World Publishing Co., New York, 1970, p. 71.

¹⁰ R. S. Norris and collaborators in the *Bulletin of Atomic Scientists* 2002, 2005-2008 (see also Refs. 1 and 5).

¹¹ See, for instance, I. Hilgevoord (Ed), *Physics and our View of the World*, Cambridge University Press, 1994; B. C. Van Fraassen, *The Empirical Stance*, Yale University Press, New Haven, CT 2002; M. Ruse, *Is evolution a secular religion?*, *Science* **299**, 1523 (7 March 2003); M. Ruse, *The Evolution-Creation Struggle*, Harvard University Press, Cambridge, Massachusetts, 2005.

¹² *New York Times*, December 20, 2005; G. Vogel, *Science* **310**, 1595 (9 December 2005); D. Normile and G. Vogel, *Science* **310**, 1748 (16 December 2005); See also A.E. Shamoo and D. B. Resnik, *Responsible Conduct of Research*, Oxford University Press, New York, 2003; *Science* **327**, 1591 (26 March 2010).