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The Universality of Science: Limits and Needs

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In this lecture, I shall attempt to broaden the definition of the universality of science to include the universal acceptance of science by society. I shall outline some of the limits to and some of the needs for this universality.

The advancement of science has been unimaginable and the scientific frontier endless. Similarly profound has been the impact of modern science on man. 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 good fraction of society fear science's impact on man and think that science has "set its own conditions and imposes its own values"¹ on society, and many agree with Vaclav Havel that "Modern science describes a single dimension of reality... and the fewer answers the era of rational knowledge provides to the basic questions of human being, the more deeply it would seem that people, behind its back, cling to the ancient certainties of their tribe."²

I shall first look at a few distinct universal characteristics of science, and then focus on the limits to and needs for the universality of science.

1. Universality is a Distinct Characteristic of Science

Science is universal in at least two fundamental ways:

First, with regard to the applicability and validity of its method, the generality of the physical law, and the effects of scientific knowledge on human functions.

Second, with regard to the participation of humankind in it; science's growth is rooted in the discoveries of all nations, and the knowledge it provides is (or can be) universally-shared, constituting a common heritage of humanity. There is one science, open, in principle, to everyone, which unites humanity.

A prerequisite of the universality of science is freedom of work and communication in science, wisdom and caution in the application of scientific knowledge, and opportunity for every nation and every generation to participate in, and profit from, science.

I wish to stress six limits to the universality of science.

2. Limits to the Universality of Science

First Limit: The preponderance of humanity is still not participating in the advancement of science and does not share the fruits of scientific knowledge

To ICSU, and to other scientific organizations, the Principle of the Universality of Science entails “freedom of movement, association, expression and communication for scientists, as well as equitable access to data, information and research materials.”³ These scientific freedoms are coupled to responsibilities.

Although today science transcends locality, it still bears the imprint of locality. And although we demand freedom, often we forgo responsibility.

Today, most of the scientific research is done in the developed nations of North America, Europe, and Asia. About 95% of the world’s R&D is conducted by the 20% of the technically advanced peoples. In spite of recent progress, neither the scientific knowledge nor the scientific technology is available to the majority of the world. Most developing countries are practically with little or no science.⁴

In today’s world, the scientific and technological isolation of most of humanity is clearly not acceptable. Without proper access to scientific literature and technical information, and without adequate means and materials needed for their indigenous science and technology, *developing nations will continue to remind us of the limits of the universality of science.*

The ICSU European members argued for “open access” to the scientific literature at the 29th General Assembly of ICSU in Mozambique in October 2008, and the following text was adopted: “In line with the Principle of Universality of Science, ICSU maintains that the denial of access to a substantial part of the scientific literature without subscription constitutes a serious impediment to the advancement of science. ICSU will explore ways to promote open access to all scientific literature by every scientist anywhere in the world.”

Second limit: The “limitless power” of the method of science

The ability of science to answer questions which can be defined scientifically is limitless.⁵ *The impression that there is no limit to what science can do, limits the universality of science.* For there are limits, even within the borders of science.

Systematically, modern science has reduced the natural world to molecules, atoms, nuclei and their constituents and on the basis of this knowledge at the fundamental and elemental level succeeded in establishing the physical law and the order of the physical world based on the validity of the physical law. In this “reductionist” 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 power and 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 life on the other hand – is of paramount significance. And this is so, 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 of size and complexity. Composite systems, which are continuously interacting with their environment, are continuously changing and attain new properties which may be autonomous, that is, not reducible to concepts and theories describing the behavior of their constituents. This becomes clearer when one deals with live organisms, which may have their own laws, which, while not in opposition with the known laws of physics, cannot be reduced to them, because the understanding of living organisms is not possible with only the knowledge of the atoms that constitute them. The whole is manifested in the particular, and yet it has properties of its own. Furthermore, many scientists have stressed the need to consider holistic properties and teleology issues. Neither is it possible to comprehend the basic phenomena of life on the basis of the known laws of physics, nor is it possible to understand man only by a reductionist’s view of him.

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 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?”; “If matter evolved according to the laws and forces of nature, what is the origin of these laws and these forces?”. These are questions that science can ask, but science cannot answer.

As scientists we can express opinions about these questions, but we cannot provide scientific answers. Questions of this nature show that although the borders of scientific knowledge are continuously expanding, some questions remain; they belong to the area of “trans-science”.^{5,6} *The pretension that we have scientific answers for such questions, limits the trustworthiness of science and its universality.*

Third limit: Issues beyond the province of science

Science is not the only way to the truth. The world is a hybrid of many things, and there are other, complementary, ways to the truth. 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. Science deals with neither ethical judgments nor with the ultimate meaning of life. I do not know of ontological experiments in science. Neither do I know of physical laws which impose the respect for human rights or the love of our fellowmen. 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 and 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 transform science to a myth, limits the universality of science.*

The general acceptability of science is largely due to the fact that science makes no metaphysical claims. When that premise is abandoned, science is judged differently and faces many problems which, undoubtedly, *limit its universality.*

Fourth limit: 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, truthfulness and human dignity; reciprocity – are mutually embedded and mutually indebted; they guide human behavior and constitute the 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. Science confronts the work of a scientist with the work of his colleagues and cannot survive without justice, honor and respect among them. Science, furthermore, is based on the free communication among the 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, and because science itself is first and foremost a human activity. Thus, while the scientific picture of the world changes continuously, the values on which science and scientific behavior are based remain fundamentally the same: timeless, universal 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 earlier, “If deep in the essence of civilization lies the emancipation of humanity, society cannot be truly civilized without science.”^{5,7} 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 as antagonistic to accepted beliefs, norms, and values, and as increasingly questioning the traditional foundation of Western Civilization. *The degree to which science and society are successful in this endeavor will enhance or limit the universality of science.*

There is also another aspect of this limit of science, namely, the **fears** of society that the scientific view of life diminishes man. These fears are especially deep with regard to the consequences of scientific knowledge/view of the concept of 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. This is progressively more evident in two pivotal areas: the views about the origin of humanity and the views about the becoming, the evolution, of humanity. *The view from science, as presented by most scientists, clashes with the view that man is the unique creation and the supreme value par excellence.*

Furthermore, many fear 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.^{8,9,10} Independently of the validity and the extent of these fears, it is evident that *the downfall of man unavoidably means the downfall of science.*

Fifth limit: Science is perceived as power to suppress and to destruct

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.”¹¹ 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.

The fear that science is increasingly becoming a power for suppression and destruction and the perception that science is no longer in the hands of the scientists limits the universality of science.

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
PRC	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.¹²

Sixth limit: The careless scientist

Scientists often step over the scientific norms and become antagonistic in matters not scientific. 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. Geneticists tell us that they have discovered “The Language of God,” theoretical physicists that they have discovered “The God Particle,” astronomers that they have discovered “The Mind of God,” evolutionary biologists that they have discovered “The Selfish Gene,” and still others that they have discovered the “Theory of Everything.”

No wonder, there are genuine fears in society that science is phasing into scientism.

We must go back to our scientific tradition, which teaches modesty and tells us to confine ourselves to questions that science can answer.

Equally discomfoting is the fact that scientists frequently abdicate their responsibility to the norms of science in favor 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).

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.”

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

3. Needs for the Universality of Science

For science to become truly universal,

- The trust of society in science and the scientist must be safeguarded and indeed must be enhanced; the most significant factor in effecting this goal is the responsibility of the scientist.
- The scientific culture and the humanism inherent in science need to be effectively transmitted to society.
- The scientists should address the fears of society with modesty and must respect the dignity of man.
- The values of science and the traditional values of society need to achieve mutual accommodation.
- Science needs to work with society to address the ferocious problems facing humanity today – such as those of war and peace, deterioration of the environment and climatic change, and wide-spread poverty – for which a strong science is necessary, but is not sufficient.
- Science needs to reassess its deep involvement with the machinery of war.

4. References and notes

¹ D. A Schon, *Beyond the Stable State*, Random House, New York, 1971, p. 22.

² Havel, V., *The Need for Transcendence in the Postmodern World*, Speech in Independence Hall, Philadelphia, July 4, 1994.

³ ICSU, *Freedom, Responsibility and Universality of Science*, 2008, ISBN 978-0-930357-68-9.

⁴ This is pointed out by many agencies and organizations, foremost the International Council for Science (ICSU).

⁵ L. G. Christophorou, *Place of Science in a World of Values and Facts*, Kluwer Academic/Plenum Publishers, New York, 2001.

⁶ A. M. Weinberg, *Minerva* **10**, April 1972, p. 209; *Science* **177**, 21 July 1972, p. 211.

⁷ Λουκάς Γ. Χριστοφόρου, *Βήματα στην Επιστήμη και τη Ζωή*, Σύλλογος προς Διάδοσιν Ωφελίμων Βιβλίων, Αθήνα, 2009.

⁸ L. R. Kass, *Life, Liberty and the Defense of Dignity – The Challenge for Bioethics*, Encounter Books, San Francisco, 2002.

⁹ G. Stock, *Redesigning Humans – Choosing our Genes, Changing our Future*, Houghton Mifflin Company, Boston, 2003.

¹⁰ C. S. Lewis, *The Abolition of Man*, HarperSanFrancisco, 2001 edition.

¹¹ I. I. Rabi, *Science: The Center of Culture*, The World Publishing Co., New York, 1970, p. 71.

¹² R. S. Norris and collaborators in the *Bulletin of Atomic Scientists* (see also Refs. 5 and 7).