

Weinberg A M. Science and trans-science. *Minerva* 10:209-22, 1972.  
[Oak Ridge National Laboratory, TN]

Predictions of rare events—for example, the estimate of the number of deleterious biological effects resulting from exposures to environmental insults at dose levels far below the levels at which effect can be seen—lie beyond the power of science. Such questions, which are isomorphic with questions that can be answered by science, are designated as “trans-scientific.” Many of the most urgent policy issues, particularly the establishment of regulatory standards for exposure to low-level insult, involve trans-scientific, not scientific, questions. [The *SCI*® and the *SSCI*® indicate that this paper has been cited in more than 105 publications, making it the most-cited article published in this journal.]

## Origins of Science and Trans-Science

Alvin M. Weinberg  
Medical Sciences Division  
Oak Ridge Associated Universities  
Oak Ridge, TN 37831-0117

I coined the word “trans-science” at the time Oak Ridge National Laboratory was becoming involved in the debate over nuclear power—in particular the debate over the hazard of low levels of radiation. The public’s exaggerated estimate of risk was at the root of the difficulties nuclear energy was facing.<sup>1</sup> If ever there was a trans-science question, this was it.

After the paper was published, Harvey Brooks added another dimension to “trans-science”—the evolution in time of systems governed by large classes of nonlinear equations. Poincaré was one of the first to stress that the ultimate behavior of such systems is sensitive to tiny perturbations in the initial

conditions. Chaos is a manifestation of such Poincaré instabilities. Brooks suggested that an analysis of such situations was beyond the power of mathematics, and therefore, was trans-scientific.<sup>2</sup>

The term “trans-science” is used quite widely now. Perhaps most notable was W. Ruckelhaus’s admission in 1985 that many of the EPA’s regulations hang on the answers to questions that can be asked of science but cannot be answered by science—i.e., are trans-scientific.<sup>3</sup>

In this present Age of Anxiety, we have become a society of very healthy hypochondriacs. Although life expectancy in the West has increased by an astonishing 20 years during the twentieth century, we worry more than ever about small environmental insults that may be carcinogenic. That science cannot shed much light on the biological effects of low-level insult is gradually being recognized in many quarters. For example, W.G. Wagner concludes: “... in order to accommodate trans-science, the judicial framework must change.... Trans-scientific obstacles can be circumvented by referring to more predictable notions of qualitative causation and unreasonable conduct—(thus) the courts may be able to reincorporate the principle of deterrence into the adjudication of toxic torts.”<sup>4</sup>

In addition to giving a name to an idea that regulators and toxic torts lawyers had been grappling with, “Science and trans-science” has added another dimension to the perennial quest for limits to science. To the limits of science posed by Heisenberg’s uncertainty principle, or the second law of thermodynamics, or, in a different sense, by society’s limited ability to support science, we now speak of a “trans-scientific” limit as a distinct philosophic category.

1. Weinberg A M. Risk assessment, regulation, and the limits of science. *Proceedings of the Symposium on Phenotypic Variation in Populations: Relevance to Risk Assessment*, December 7-10, 1986. Brookhaven National Laboratory, 1986. p. 121-6.
2. Brooks H. Letter to editor. (Science and trans-science.) *Minerva* 10:484-6, 1972.
3. Ruckelhaus W. Risk, science and democracy. *Issues Sci. Technol.* 1:19-38, 1985.
4. Wagner W G. Trans-science and torts. *Yale Law J.* 9:428-49, 1986.