ISSN 1233-1821

FOUNDATIONS of SCIENCE

VOLUME 1, NUMBER 1, 1995/96

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THE FOUNDATION OF SCIENCE

To address the question "What is the foundation of science?" I base my response on the two substantive constructs of the question: *science* and *foundation.*

Science. Science conveys to me the idea of pursuit in order to comprehend. It is first a process and second a result. The process is that of discovering and the result is the discovery. The process becomes a way of knowing and the outcome some form of knowledge. More recently, scientists have come to understand that the process is more creative than previous assumed, and consequently some forms of science involve not only discovering, but also creating. The status of knowledge has taken on a more temporary, transitory quality, as scientists create more informative and useful manifestations of knowledge, periodically revising them to better reflect their comprehension of reality.

As the phenomena of interest in my professional work concerns human beings, those sciences directly relevant to people, I term the human sciences, preoccupy my attention. As a methodologist, I concentrate my study on those research methods which scientists use to study human phenomena, and I term such methods human science research methods. As the forms of science differ, or perhaps more accurately advance, the forms of method do also.

Interestingly, scientists devote much time in the process of discovery and creation to both the phenomena under study and their methodology. By this I mean that scientists invent, refine, and improve their technologies, techniques, and various means of inquiry in their pursuit of knowledge. There is an important and reciprocal relationship between what we know and the technology we employ. Advances in science technology lead to advances in scientific knowledge, and vice versa.

However, human science is changing in another fashion. In addition to greater recognition of creation in the acts of scientists, the aim of science is undergoing a genuine expansion. This expansion is coming to redefine what we mean by science.

In traditional forms of science, it is assumed that the scientist, a skilled observer standing somewhat aloof from that which is studied, need only apply the proper methodology to reveal the workings of Nature. Answers to research questions exist; they await the clever scientist to uncover them. Moreover, in the last century, it was recognized that the knowledge of the scientist is both public and personal, and both may be socially based constructions bounded by the worldview, that is the underlying paradigm ascribed to by the scientist. One interpretation may not represent those of other scientists or general laws of Nature. Doing science extended from active reflection upon what one is doing to include interaction with the phenomenon studied and participation in an ongoing dialog and critique of findings and means of discovery. Reminiscent of the contribution of Copernicus, whose science brought about a shift from the theocentric and geocentric worldviews to the heliocentric worldview, importantly, a controversy in the middle of the 19th century divided scientists between the natural science (heliocentric) worldview leading to explanation and the human studies (anthropocentric) worldview leading to understanding. This historical development in the history of science represents the culmination of an emerging shift away from a heliocentric worldview that is still taking place today. Though the usual outcome of participation in such debates among scientists – then and now – has been to favor one position to the rejection of the other, I believe what we witness from each debate is a recognition by more scientists that multiple

worldviews are relevant to science. Each one has assumptions which may be at variance from the other, and each serves somewhat different interests among scientists. More specifically, where the natural science worldview (arena 1) involves the discovery and formulation of knowledge which promotes public and consensually supported explanations of phenomena, the human–centered, humanistic worldview (arena 2) emphasizes the personal understandings of the scientists and research participants engaged in the inquiry. Each arena serves different science interests. One is neither more or less important than the other. But both exist and should be recognized and articulated.

By the middle of this century, a third arena emerged in which the main aim of the scientist became the amelioration of human conditions. This form of inquiry has become variously known as social action, social intervention, and participatory action research, and its methods of conducting science are at variance with those of the first and second arenas.

My view of the matter is that the three arenas demonstrate the multitude of interests among scientists as well as the purposes to which they apply their science. The arenas reflect the underlying paradigms that influence the conduct of inquiry. I expect more arenas to emerge with further advances of science. Therefore, in any consideration of the foundation of science, it is important to emphasis that there are different forms which science can take. These forms constitute science in its broadest pursuit of knowledge, and we need all kinds of scientists to study our complex problems.

As a methodologist, it is most challenging for me to work with the three arenas stated, because I believe that they are not contradictory or oppositional: to the contrary, they have an important complementary, often nested, interrelationship. Currently, I am witness to many scientists in Europe and the United States who are discovering that human science research methods can be combined in various ways to create a more productive, effective and informative methodology. I provide two examples. Naturalistic observation (arena 1), nonparticipant observation (arena 2) and participant observation (arena 3) may be combined to construct an observation methodology, which is often the case in ethnographic research in anthropology. In management science, a social action research project may involve a survey (arena 1), followed by interviews (arena 2), and finishing with focus group discussions (arena 3), from which the researcher converges upon the findings in order to make recommendations to improve the institution.

In summary, science consists of means of inquiry in pursuit of knowledge relevant to aims. The aims of science may be to 1) provide an explanation (publically debated theory) of the phenomenon, 2) deepen the personal un-

derstanding of the scientists and participants engaged in the inquiry, and 3) ameliorate human conditions. Of course, there are many possible aims and interests of scientists not stated here, but I have found these three to be most dominant; thus I characterize each to represent their underlying paradigm of science.

Foundation. As to the second key construct in the question, the most fundamental concepts and principles provide the foundation of science. Without them, the scientist cannot engage in doing science. Of course, it follows from the first section of this statement that this foundation consists of the methods, knowledge, and aims of scientists.

Science is first descriptive. Descriptions of phenomena require a common set of tools and a language by which scientists work. The application of fundamental concepts and principles to 1) methodology, 2) knowledge creation, utilization, and revision, and 3) scientific interest gives substance to science. Foundation means a stable dependable basis with which one can work. It also means a solid ground upon which to stand to build theory, mature personal understanding, and act in concert with others for changing living conditions.

Fundamental concepts and principles are especially those that cut across all sciences. Such exemplars as observation, interpretation, triangulation, and replication are critical concepts to know, if one is to know what scientists do. Understanding these concepts is paramount in praxis of inquiry which is efficient, effective, and fruitful.

There is by no means widespread agreement among scientists as to what constitutes scientific interests, scientific method, and scientific knowledge. The very foundation of science has been challenged in regard to the assumptions scientists make about purpose, method and knowledge. Variations in position on these matters are evident in the assumptions and beliefs of scientists who work in each arena of inquiry. Is it possible that knowledge can represent explanation, understanding, and amelioration? Are the means scientists use to obtain explanation, understanding, and amelioration different forms, and legitimate forms, of scientific method? These are controversial subjects.

Remarkably, there are many constructs which unify scientists. Such a construct, for example, is information. It has an intriguing relation to knowledge. Despite variations in the definition of this term, information is an example of a basic concept that has a unifying effect on the sciences. It has become one brick, so to speak, of the foundation. It enables communication among scientists across the sciences and fosters the advancement of science. Furthermore, it is not the linguistic label itself that I emphasize, but what it

stands for, that is, the phenomenon that it represents. In other words, information is isomorphic. The concepts and principles, that scientists discover which are isomorphic, are those that contribute essentially to the foundation of science. The more isomorphic the concepts and principles are, then the more generic the science.

In contrast to single constructs like information, there are interrelated sets of them that also importantly contribute to the foundation of science. General Systems Theory may be an outstanding example of a theoretical approach to science comprised of a set of interrelated constructs that tend to be isomorphic in their application across the sciences.

Methodology represents my major interest in the foundation of science. Like a stone cutter and bricklayer who must know his tools well in order to build a solid foundation for a home, a human–oriented scientist must be most familiar with various methods of human science research in order to conduct fruitful inquiry. As necessary, this activity includes development of new and innovative science technologies which advance the aims of science. At the turn of the century, advances in methodology are expanding the foundation of science. Scientists are combining methods in new ways and making every more creative the means to innovate methodology. Presently, the range of methods and possibilities to combine them are staggering. To give but one illustration: The multitude of media–related technologies today enables scientists to study human activity through not just video, email, and other electronic data trails, but additionally by means of several types of microscopic scanning into the human body and macroscopic pattern imaging from global satellite networks.

In conclusion, the foundation of science is the more enduring and substantive concepts and principles as expressed in the aims, methods, and knowledge of scientists. Although on the surface the foundation may appear static, this stasis is illusionary. Under the surface, the foundation is very turbulent. Scientists are in continuous debate over the interpretation of evidence, the proper scientific method for the phenomenon studied, and the purposes served through inquiry. Science involves reflective, critical, speculative, and creative activity. It is this activity that guarantees continued vitality and evolution of the foundation of science.