TRANSDISCIPLINARITY:
recreating integrated knowledge

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3 *Perspectives from Social Scientists and Humanists*

3.1 *Transdisciplinarity for Problems at the Interstices of Disciplines*

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SOME CONSIDERATIONS ABOUT TRANSDISCIPLINARITY

The first thing that comes to mind when I hear the term "transdisciplinarity" is problem-centered investigations in contrast to "discipline-centered investigations." Disciplines provide methods of investigation and theoretical frameworks that inform the methods of inquiry. The questions asked are based on what has been accomplished in the past. Natural science is largely incremental. We build on prior work. The lattice of concepts and theories is self-reinforcing. It is only during periods of major paradigm shifts or scientific revolutions when one experiences the collapse of the entire structure. That may mean the theory has been replaced, but it doesn't necessarily imply that the empirical results are discounted or invalid. That will depend on how closely connected the data and the theory are.

Transdisciplinarity suggests that one's queries and investigations are not bound by disciplinary norms. Sometimes, the demarcations in science are fairly obvious. The positivist tradition that looms so heavily in science today distinguishes normative from descriptive/empirical analysis. If you are working in a field like molecular biology, you become interested in questions about gene structure and function. You choose an organism and develop a system to study genetic controls. But there are questions that fall outside the proper boundaries such as: what are the ethical implications of discovering a genetic switch to aging? Or, why is so much emphasis given to inherited genetic diseases and so little given to developmental genetic abnormalities (Levins and Lewontin 1985)? These normative questions may require knowledge of the science of genetics *and* the social structure of science. Investigations into

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the latter questions are not publishable in the traditional journals of the field.

Transdisciplinarity also suggests that some questions are best treated by combining two disciplines or at least their methods of analysis or theoretical frameworks. This type of transdisciplinarity occurs throughout the scientific disciplines and serves as the precursor to newly formed and hybridized disciplines. Fields like psycholingusitics or sociobiology are some examples where two disciplines form a hybrid. The entire enterprise of risk analysis has been hybridized from different disciplines (Krimsky and Golding 1992). The methods or techniques of one discipline help to pose and answer questions generally associated with another. Anthropologists interested in migration patterns of ancient societies link up with geneticists who, from human remains, can examine genetic homology among population groups that will provide evidence that helps resolve certain puzzles of the field. The process of disciplinary mergers can expand the evidentiary base for an established research program in one field. Some people might call this *interdisciplinarity*, namely the partnership of two disciplines to expand the theory or evidence in support of certain hypotheses. Recall the partnership of Watson and Crick from the disciplines of biology and physics that resulted in the discovery of the double helix and eventually spawned the new field of molecular biology. In other cases, new fields are developed by turning the lens of one field onto another. That's how philosophy of science and linguistic philosophy developed. The field of ecological economics emerged from problems that lie at the boundaries of both fields (Costanza 1991).

Some people might view the term "transdisciplinarity" as meaning "outside the disciplines." It would be quite difficult to pose a query that is outside all disciplines. Some discipline would claim ownership of some part of the query. Likewise, it would be difficult to find a method of measurement or of acquiring information or evidence that is outside all disciplines. So, if we speak of "transdisciplinarity" as meaning outside of all disciplines (organized fields of knowledge), it imposes too great a burden on the term.

"Transdisciplinarity" has a certain fluidity. It suggests that one is not bound by disciplinary canons in any one field. The term "transcendence" is appropriate here. There are certain classes of questions that transcend a single discipline. One such class of questions pertain to the synthesis of knowledge. For example, what can we say about human freedom and determinism? This question requires an examination of the recent contributions of many fields of knowledge including genetics, neurophysiology, physics, behavioral psychology, to name a few. In this context, "transdisciplinarity" is a type of meta-analysis. It seeks unifying themes from the contributions of diverse disciplines. It involves the construction of a "metatheory" from many disparate sources of knowledge.

Other expressions of "transdisciplinarity" relate to questions that are at the interface of two or more fields. Such questions are not so much outside disciplines but are rather situated within overlapping disciplines. A current example of this type of investigation can be found in the "Environmental Endocrine Hypothesis." In the late 1980s, discoveries of wildlife abnormalities in the Great Lakes led one investigator to posit a theory that chemical contaminants of the lake were behaving like hormones in the animal systems, and that these xenobiotic (rogue) hormones were affecting the sexual development of the organisms (Colborn et al. 1996). The most generalized formulation of the "Environmental Endocrine Hypothesis" has implications for more than twenty-five diseases in animals and humans, including breast and prostate cancer, cognitive deficiencies, behavioral changes, intersex (organisms developing with male and female sex characteristics), and sperm deficiencies. The broad scope of this hypothesis makes it "transdisciplinary" in the sense that the evidence required to dispute it or support it derives from many different disciplinary sources including endocrinology, wildlife toxicology, neurobiology, molecular and cell biology. When such a broad hypothesis is framed that intersects so many disciplines, the problems of confirmation or falsification are complicated.

Just consider one subhypothesis in the general "environmental endocrine hypothesis," relating in utero chemical exposures to declining sperm count in human males. The subhypothesis requires evidence that: 1) there is a general decline in sperm count and quality in the human male population; 2) there is in utero exposure of foreign chemicals at sufficient levels to diminish the number of sertoli cells; 3) the diminution of sertoli cells can be associated with lower sperm quality and quantity; 4) a biological mechanism exists by which foreign chemicals act like hormones affecting the development of the human male, altering sertoli cell production. The transdisciplinarity of this exercise requires one to piece together the contributions to the question from fields like epidemiology, reproductive toxicology, urology/andrology, and endocrinology.

In conclusion, the term "transdisciplinarity" has several meanings to me: the transcendence of disciplines for addressing meta-questions; the intersection of two or more disciplines for explicating problems; and the combination of methods/techniques/theory from several disciplines in the framing or testing of a hypothesis.

EXPERIENCE WITH TRANSDISCIPLINARITY

I was trained/educated foremost as a philosopher. The five years of intensive graduate study, for which I was awarded an MA and a Ph.D., provided the core of my training. I also studied physics as an undergraduate and for two years as a graduate student. I never thought of myself as having worked out a distinct tradition or theoretical framework for investigation. But epistemology was always a central theme in my research and teaching. Initially, the issues of primary interest to me involved the form and nature of scientific inquiry, the structure of scientific explanation, and the metaphysical and trans-scientific foundations of science.

Somewhat later, I began applying these issues to the role of science in public policy. The issues grew directly out of philosophy. What claim can science make to providing objective truth? What role does value play in the scientific enterprise? What normative themes arise in scientific inquiry? How does science function in informing public policy?

Several years ago, I teamed up with an ecologist and entomologist on a problem pertaining to the ecological effects of genetically engineered crops. The team agreed that we should examine the documentation and decisions of the US Department of Agriculture in its review of industry proposals for field testing genetically engineered crops. Our research method involved the analysis of submissions by companies that had a genetically engineered product. The USDA was responsible for undertaking an environmental assessment of the new transgenic crops. My colleagues and I focused on the risk assessment, that is the risk parameters that were used in the assessment. The scientists in the group were interested in whether the USDA had dealt adequately with all the risks. I, on the other hand, was interested in the structure of their evidence. What was the epistemic basis of their claims? My contribution was to situate the risk parameters in an epistemic framework. I am confident that this method of analysis would never have occurred to my scientific colleagues.

I focused my piece of the analysis on evidentiary support for scientific claims. On what basis did the regulators justify the approval of the field-test proposals? I created a number of evidentiary categories for the person reviewing the environmental assessments written up by the USDA. There were six categories that were introduced into a matrix along with concepts from ecology describing ecological risks. We had our research group categorize all claims of the USDA that pertained to the safety or risks of transgenic crops into the following areas: new experimental data; literature cited without new data; use of theory or general principles (evolutionary ecology); criteria of negative evidence (no information indicating a problem); experiential evidence (familiarity of reviewer with the organism in question); unsubstantiated statements (assertions made about risk without support of any type).

By combining the epistemic framework and the risk factors, we were able to show a pattern of evidentiary support that provided insights into the type of weighting done by the USDA and the bias towards certain types of evidence. The article was eventually published in *BioScience* and may have had some impact on regulatory policies thereafter (Krimsky et al. 1992).

In another collaboration, this time with an ecologist and a microbiologist, the topic was developing a system for evaluating the risks of releasing genetically-engineered microorganisms into the environment. This project was defined by an interdisciplinary grant offered by EPA through a center at Tufts University. Each of the three participants had a focused research goal; the participants were supposed to collaborate on each of the goals with the expectation that the multidisciplinary inputs would be reflected in the work and that a synthetic piece of analysis would emerge.

The more policy-oriented members of the team were able to benefit from the scientific projects, but there was little evidence that the scientists had benefited from the policy/philosophy discussions. This was more a case of multidisciplinary linkages than "transdisciplinarity." The microbiologist advanced the idea of soil-core microcosms to evaluate the possible risks of genetically engineered organisms before they are released into the environment. This was a highly empirical investigation involving measuring the movement of microbes through a soil-core system. The ecologist developed a model for the spread of genetically engineered microorganisms into the environment using the data from the soil-core experiments. The policy group asked the "bigger" questions about the role of standardized microcosms in risk assessment of genetically engineered microbes. This paper integrated regulatory policy, science, and risk assessment and thus had to show competencies and knowledge of the literature in all the fields. This was the only group that published a paper that included all the participants (Krimsky et al. 1995).

TRANSDISCIPLINARITY AND PRESSING SOCIETAL NEEDS

One of the most pressing issues of our time is the rising rate of diseases of unknown etiology. In the United States and many industrialized nations, breast and prostate cancer fall into this category. Many of the national research efforts directed at discovering the causes of these diseases have followed a reductionist approach. Funding agencies heavily support research on cell transformation, cell proliferation, and the genetic precursors to the disease. In recent years, patient advocacy and self-help groups have grown. In the area of breast cancer, some of these groups have lobbied state and federal governments to pursue the environmental causes of cancer. Many breast-cancer activists believe that the increasing use of and human exposure to synthetic organic chemicals may be playing a role in the rising incidence of breast cancer, while others believe the same is true of prostate and testicular cancer.

If we are going to make any progress in understanding what (if any) role chemicals play in cancer, it will take a major transdisciplinary effort. We will have to understand what types of exposure to chemicals people get at different stages in their lives; whether certain chemical exposures and certain genotypes are more likely to result in cancer; whether in utero exposures to synthetic chemicals increase the risk of contracting cancer in later years; whether diet is a factor in the risks of breast or prostate cancer. Today, many of these investigations are taking place in parallel. The linkages between the diverse disciplinary studies in cancer epidemiology, cell biology, genetics, nutrition, and toxicology are poorly developed. The synthetic activity of developing metatheory across the different studies and disciplinary approaches seems to be at its infancy. We have not been able to account for breast-cancer hotspots in certain areas of the world and we have meager conjectures to explain country differences in breast-cancer incidence.

Cancer research has become an industry. As a result, different sectors of that industry have vested interests in certain approaches. Transdisciplinarity would require an openness to alternative modes of understanding the disease and better linkages between the reductionist and more holistic paradigms of inquiry. For example, the human genome initiative has focused almost exclusively on inherited diseases. It could also be used to study the effects of chemical exposure on genetic mutation. Epidemiologists have done case-control surveys on breast-cancer populations to identify possible factors that could explain the onset of the disease. Environmental scientists have taken extensive measurements of air and water in areas with high breast-cancer rates to determine whether there are higher rates of chemical exposures correlated with elevated breast-cancer cases. Geneticists study the family trees of cancer victims. Physical anthropologists look at sociobiological factors such as nutrition and early menarche or age of first pregnancy. Each of these areas produces insights into a small piece of the problem. A more integrative approach could yield new fruitful and testable hypotheses. This is the essence of transdisciplinarity – looking at the big picture and building a solution to a problem from the disciplinary segments.

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