The National Cancer Institute's Transdisciplinary Centers Initiatives and the Need for Building a Science of Team Science

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Introduction

When the National Cancer Institute (NCI) was reorganized by former Director Richard Klausner, a new Division of Cancer Control and Population Sciences (DCCPS) was established in the Fall of 1997. Under the leadership of Drs. Barbara Rimer and Robert Hiatt, the division rapidly set out to reinvigorate the science of cancer control through the development of new initiatives in surveillance, epidemiology, health services, behavioral, and cancer survivorship research. One important assumption underlying these efforts was that the speed of scientific progress and its effective application to public health problems would depend on the integration of discipline-specific efforts and increased support for collaboration, evidence synthesis, and the science of dissemination.[1] A key strategy for achieving those goals was the development of new transdisciplinary team science research centers, focused on four problem domains that were seen as critical barriers against effective cancer prevention and control: tobacco use, health disparities, obesity, and poor communication. Although these four initiatives were housed within the new Behavioral Research Program within DCCPS, it was clear from the outset that to effectively accomplish the program objectives, both the centers projects and investigators would need to span a wide range of disciplines, from molecular biology to policy studies.

Soon after I moved to NCI in July of 1998 as the first Associate Director for Behavioral Research in DCCPS, I had the privilege of developing the Request for Applications (RFA) for the first of the series of transdisciplinary science initiatives. The Transdisciplinary Tobacco Use Research Centers (TTURCs) were developed and funded in collaboration with the National Institute on Drug Abuse (with the support of Jay Turkkan and Alan Leshner) and the Robert Wood Johnson Foundation (with the support of Nancy Kaufman and Tracy Orleans).[2,3] It is important to remember that in the late 1990s, when this effort was launched, *transdisciplinary* was an unfamiliar term in biomedical and behavioral research. The NIH Roadmap had yet to be conceived. In fact, some members of NCI's Board of Scientific Advisors disputed whether *transdisciplinary* was a word at all!

A lot has changed in the past decade. One scholar, noting the recent popularity of all things *interdisciplinary* or associated with *interdisciplinarity* in academia, complained that "so powerful are the I-words that it is difficult to oppose anything (including top-down allocation of resources) done in their names—and cynical speculations abound that a person or committee's proclaimed commitment to them is strategic, not heartfelt."[4] But despite the skepticism, both universities and research funders have continued to invest in new programs to grow interdisciplinary research. NCI launched the Integrative Cancer Biology Program, Stanford University initiated the Bio-X Program, and several centers, training programs, and research projects were funded through the Interdisciplinary Research component of the NIH Roadmap initiative. One of the most distinctive efforts supports not only a newly constructed physical infrastructure, but also the scientific projects conducted there. The new Janelia Farm facility in Virginia, funded by the Howard Hughes Medical Institute, houses an interdisciplinary neurobiology center for high-risk, collaborative research.[5] Janelia Farms is a grand experiment in a new way of doing science, and many observers will be watching closely to see the outcome.

Two critical concerns emerged from these efforts: (1) the relative merits of these investments versus traditional discipline-specific activities, and (2) how best to ensure their success. Funders and investigators alike are asking: *How do we evaluate interdisciplinary and transdisciplinary team science?*

Once the TTURCs were launched, it immediately became clear that the NIH, including NCI, had no clear metrics for evaluating problem-focused centers initiatives like the TTURCs. In addition, the specific goals of the TTURCs, which included the development of novel transdisciplinary team science and training, were based on assumptions about how best to facilitate scientific progress that had yet to be tested empirically. Therefore, it was clear that the TTURCs presented both a

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challenge to the science of evaluation and an opportunity to develop new evaluation methods by studying the process and outcomes of transdisciplinary science itself.

The logical next step was to initiate an evaluation methods development effort focused on the assessment of constructs, such as collaboration and transdisciplinarity, that were deemed essential to the process of planning and conducting transdisciplinary science. The ELI (Evalution of Large Initiatives) Project, as we called it, was initially designed as an effort to specify, measure, and understand the transdisciplinary science goals and processes within the TTURCs. However, at the very outset, we also conceived it as a pilot project for a longer-term effort to develop an evaluation toolkit for a variety of large science initiatives. We asked Bill Trochim of Cornell University to lead this initial effort, which is described in a recent publication[6] and in the Masse et al.[7] article in this supplement.

From these early experiences, as well as the challenge of evaluating subsequent centers' initiatives (e.g., Centers for Population Health and Health Disparities, Centers of Excellence in Cancer Communication Research, Transdisciplinary Research in Energetics and Cancer centers), it became clear that an expanded effort focusing on the "science of team science" was merited. We asked Dan Stokols to lead this second phase of the ELI project, which included the evaluation of the Transdisciplinary Research in Energetics and Cancer (TREC) centers, described by Hall et al.[8] in this issue, and the planning of the Science of Team Science conference that formed the basis of this supplement to the *American Journal of Preventive Medicine*.[7–21]

Building a Case for the Science of Team Science

Understandably, the consideration of new methods for evaluating scientific initiatives to complement the traditional peer review, expert opinion model raises concern among investigators. Although improvements can always be made, NIH's peer review system has served as a model both within and outside of the U.S. But it is important to recognize that funders have fiduciary, strategic, and societal responsibilities that go well beyond those that are shared by the individual investigator or scientific discipline. Federal agencies have to be accountable to a broader and more diverse set of constituencies for the productivity and impact of sponsored research. At the same time, the credibility of the peer review process for biomedical and behavioral research may be diminished if scientists strenuously advocate for the application of a scientific epistemology to their subjects but resist its application to themselves. To put it more bluntly, if we don't develop methods to evaluate our science, someone else will. Basic science is especially vulnerable, given the time lag until impact. As Gallagher[22] has argued, "Blind implementation of half-baked outcomes assessment by apparatchiks is the nightmare scenario. It could be the death of curiosity-driven research and must be actively guarded against by scientists." Our strategy for navigating these conflicting priorities has been to focus our evaluation development efforts not on the evaluation of individual studies or grants (appropriately, the domain of traditional peer review) but on evaluation at a higher level, the level of large initiatives that support a multidisciplinary group of grants or research networks.

In addition to avoiding ill-informed evaluations by nonscientists, there are at least four compelling reasons for accelerating our efforts to develop a science of team science now. First, team science is here, and the trend is not limited to biomedical research. A massive study by Wuchty et al.[23] of 19.9 million research articles and 2.1 million patent records associated with a wide range of disciplines showed steady growth in both the proportion of publications and patents by teams and the size of those teams. Second, concerns continue to be raised within the scientific community itself about the productivity of science and the appropriate balance between large-scale team science and traditional, individual-investigator-initiated studies. The National Science Foundation, for example, found that despite increases in funding, the overall number of publications by U.S. scientists remained flat.[24] This may not be a bad thing, if, as the Wuchty et al. analysis indicated, investigators who coalesce in teams are producing articles with greater impact.

Third, there are well-established bodies of research, including methods and theories, which have yet to be utilized in most studies of scientific initiatives. One reason is the existence of disciplinary silos, the very silos that transdisciplinary team science seeks to penetrate. Much of this work comes from disciplines within the social and behavioral sciences (e.g., work on teams[25] and leadership[26]), but, as the articles in this issue demonstrate, the humanities have much to contribute as well. A science of team science can build an empirical foundation to allow the experiences from one initiative to inform another[27] and produce conceptual frameworks for the integration of science across multiple levels.[28] In addition, it can lend objectivity to the evaluation of processes such as collaboration through the development of quantitative indices, such as bibliometric measures of collaboration.[29]

A fourth argument in favor of building a science of team science is the fundamental importance of training. Education can and should be a science-based activity, but to inform modern team science, we need a better understanding of how and when to initiate interdisciplinary and transdisciplinary experiences. This complex and multifaceted issue can be studied systematically at multiple levels. Sadler and Tai[30] provided one creative example of how debates concerning the sequencing of science courses and their cross-disciplinary benefits (e.g., does a physics course help performance in a later biology course) can be informed by careful educational research. They examined the relationship between high school math and science preparation and performance in college science courses. They found no evidence to support cross-disciplinary benefits of high school science courses (e.g., taking high school physics did not improve performance in college chemistry), but found strong evidence to support cross-disciplinary benefits of high school calculus. In this issue, Nash[13] explores transdisciplinary training at the graduate and postdoctoral levels, suggesting strategies for overcoming the many barriers against success in this domain.

Bridging Team Science with Public Policy

What's in store for transdisciplinary team science in the coming decade? As we continue to advance our ability to rigorously evaluate team science efforts, we also need to gradually but steadily expand the interface between large-scale problem-solving in science and the development of public policy. Traditionally, the National Academies have played an important role in this interface, but only a small minority of the many reports issued by the Academy and Washington DC–area think tanks attracts serious attention from policymakers. Congress is considering whether to revive its Office of Technology Assessment, created in 1972 but defunded in 1995, to facilitate the utilization of science in legislation. Innovations and processes that increase the utilization of scientific evidence in policymaking are sorely needed, but it remains to be seen whether scientists will step up to the plate in sufficient numbers. Too few scientists see it as their responsibility to contribute to the science policy interface. Clearly, funders can play a key role in enabling the participation of scientists in policy research, development and decision making. The Robert Wood Johnson Foundation and the American Cancer Society, for example, have supported projects with this focus, but professional scientific associations and federal agencies could do more to facilitate this interface.

Some governments are experimenting with ambitious new strategies to enable the application of new interdisciplinary knowledge from science and industry to complex societal problems. In the United Kingdom, for example, the Technology Foresight Program[31] has taken on issues such as obesity, addiction, and crime prevention, merging evidence synthesis with policy and budget development, followed by project impact assessments led by cabinet ministers. In the U.S., special commissions, working groups, and tasks forces have been created on a range of topics, but these are rarely accompanied by a sustainable implementation process that outlives changes in political leadership. The opportunities and challenges in integrating transdisciplinary team science leaders and their discoveries with non-academic sectors were well-articulated by Neal Lane, a former Director of the National Science Foundation. His call to action substantiates our reason for supporting this special issue, the need to understand the processes by which large team science efforts can be successful not only in generating new knowledge, but also in changing our strategies for disease prevention and control:

> The successful application of new knowledge and breakthrough technologies, which are likely to occur with ever-increasing frequency, will require an entirely new interdisciplinary approach to policymaking: one that operates in an agile problem-solving environment and works effectively at the interface where science and technology meet business and public policy. It must be rooted in vastly improved understanding of people, organizations, cultures, and nations and be implemented by innovative strategies and new methods of communication. All of this can occur only by engaging the nation's top social scientists, including policy experts, to work in collaboration with scientists and engineers from many fields and diverse institutions on multidisciplinary research efforts that address large but well-defined national and global problems.[32]

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