Moving the Science of Team Science Forward
Collaboration and Creativity

Kara L. Hall, PhD, Annie X. Feng, EdD, Richard P. Moser, PhD, Daniel Stokols, PhD, Brandie K. Taylor, MA

Abstract: Teams of scientists representing diverse disciplines are often brought together for purposes of better understanding and, ultimately, resolving urgent public health and environmental problems. Likewise, the emerging field of the science of team science draws on diverse disciplinary perspectives to better understand and enhance the processes and outcomes of scientific collaboration. In this supplement to the *American Journal of Preventive Medicine*, leading scholars in the nascent field of team science have come together with a common goal of advancing the field with new models, methods, and measures. This summary article highlights key themes reflected in the supplement and identifies several promising directions for future research organized around the following broad challenges: (1) operationalizing cross-disciplinary team science and training more clearly; (2) conceptualizing the multiple dimensions of readiness for team science; (3) ensuring the sustainability of transdisciplinary team science; (4) developing more effective models and strategies for training transdisciplinary scientists; (5) creating and validating improved models, methods, and measures for evaluating team science; and (6) fostering transdisciplinary cross-sector partnerships. A call to action is made to leaders from the research, funding, and practice sectors to embrace strategies of creativity and innovation in a collective effort to move the field forward, which may not only advance the science of team science but, ultimately, public health science and practice.
(Am J Prev Med 2008;35(2S):S243–S249)

Introduction

The emerging field of the science of team science draws together diverse disciplines to better understand and inform the collaborative processes and outcomes of team science. Team science can be conducted within a single, focused discipline, or can span different disciplines. The degree of variation across disciplines, as well as the breadth of levels of analysis (from cells to society), can affect the size and complexity of a given team. As such, the degree of complexity of a given problem that a team tackles can, in turn, influence the breadth and degree of the integration of disciplinary knowledge needed to explain or solve that problem. In the authors' view, the nascent field of the science of team science is currently in a descriptive or taxonomic phase of its development, during which key terms are being debated and defined as well as operationalized in specific contexts, and are being integrated into broader conceptual frameworks.[1,2] This supplement to the *American Journal of Preventive Medicine* seeks to consolidate recent work in this field by assessing a variety of conceptual issues that must be addressed as a basis for informing future team science initiatives—for instance, examining ways to categorize and measure collaborative efforts; developing models to conceptualize key aspects of the field; and devising strategies to enhance, support, and sustain team science projects.

During both the 2006 conference[3] and the development of this supplement, a variety of themes emerged that revealed knowledge gaps in the field and stimulated ideas and dialogues to guide future research. These themes pertain to: (1) the challenges associated with distinguishing between and empirically operationalizing unidisciplinary and cross-disciplinary approaches to team science and training; (2) the efforts to integrate alternative conceptualizations of multilevel readiness for team science; (3) the development of strategies for ensuring the sustainability of transdisciplinary team science; (4) the need to create new models and practical strategies for training transdisciplinary scientists; (5) the development of new models, methods, and measures for evaluating the processes and outcomes of team science; and (6) the forging of new transdisciplinary partnerships among universities, governmental agencies, nongovernmental organizations (NGOs), private foundations, and corporations.

From the Division of Cancer Control and Population Sciences, National Cancer Institute (Hall, Feng, Moser), the Office of Portfolio Analysis and Strategic Initiatives, NIH (Taylor), Bethesda, Maryland and the School of Social Ecology, University of California Irvine (Stokols), Irvine, California

Address correspondence and reprint requests to: Kara L. Hall, PhD, Division of Cancer Control and Population Sciences, National Cancer Institute, 6130 Executive Boulevard, Room 4080, Bethesda MD 20850. E-mail: hallka@mail.nih.gov.

0749-3797/08/$–see front matter
doi:10.1016/j.amepre.2008.05.007

Toward an Integrative Taxonomy of Team Science

A central focus, to date, in the taxonomy of team science relates to the number of disciplines involved in a team and the kinds of interactions that occur across different disciplines. As is evident from a number of the articles included in this supplement,[1,2,4] the predominant conceptualization thus far has been Rosenfield's[5] definitions of and distinctions among unidisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary collaborations.

Although this supplement's primary focus is on transdisciplinary team science, there is not yet an agreed-upon definition of **transdisciplinarity**. In addition to the discrepancies among different definitions of transdisciplinarity, there is also considerable debate about whether or not distinct differences exist between interdisciplinarity and transdisciplinarity. In funding, in practice, in research, and in scholarly writing, the terms **interdisciplinary** and **transdisciplinary** have been used interchangeably, referencing both similar and different connotations in various settings. Some scholars suggest that there are no differences among multidisciplinary, interdisciplinary, and transdisciplinary approaches to research.[6] The plurality of definitions and operationalizations of these concepts are embedded within the different perspectives and circumstances in which collaborative sciences are conducted. For instance, Rosenfield's definitions[5] of interdisciplinary and transdisciplinary science describe research collaborations in which the intended scientific outcomes focus on a common problem (e.g., obesity), whereas the NIH Roadmap for Medical Research[6,7] describes interdisciplinary research more broadly as involving the creation of hybrid disciplines (e.g., biochemistry, psychoneuroimmunology). Furthermore, greater clarity is needed with regard to the dimensions underlying the concept of *scientific discipline* (typically defined in terms of its substantive concerns, methodologic approaches, and level of analysis) to help further elucidate what is meant by unidisciplinary, multidisciplinary, interdisciplinary, and transdisciplinary science. Another facet of team science pertains to the definition and implementation of transdisciplinary *action research*, which involves collaborations among scientists and practitioners.[8] For example, in the field of social work, the term *interprofessionalism* has been used to describe cross-disciplinary endeavors that bridge the work of researchers with practitioners.[9]

Such variations in definitions and operationalizations of key terms can result in highly divergent measurement approaches to evaluating team science, which are likely to perpetuate confusion in the literature and impede progress in the science of team science.[1] In order to build a field with a strong science base that can be synthesized and generalized, greater clarity in basic terminology is essential for establishing a strong foundation for future studies. To better understand and evaluate the value-added qualities of transdisciplinary science, it is important that researchers in this area work together to cultivate common ground as they establish shared theoretical frameworks and measurement strategies that can be used to guide future team science endeavors.

Some of the articles in this supplement suggest that the distinctions between interdisciplinary and transdisciplinary research become more pronounced when viewed from the alternative vantage points of basic biomedical versus behavioral sciences.[10,11] To date, much of the conceptualization and investigation around interdisciplinary and transdisciplinary collaboration processes and outcomes has been led by behavioral scientists, and, as such, many of the evaluation strategies use behavioral methodologies (e.g., self-report surveys, latent variable analyses). It is clear that the study of cross-disciplinary team science (i.e., the science of team science) must bring together diverse perspectives from all levels of analysis to foster the development of a full spectrum of conceptual, theoretical, and methodologic innovations spanning multiple disciplinary boundaries. This can occur, for example, by utilizing qualitative methods to learn more about the different goals and motivations that prompt cross-disciplinary collaborations (e.g., collaborations based on the sharing of expensive laboratory equipment or specimen analyses versus those organized around the integration of intellectual ideas and frameworks spanning two or more fields); these findings can be used to develop rich conceptual and theoretical models and then can be tested in subsequent studies examining team science collaborations.

Much of the work discussed in this supplement revolves around large cross-disciplinary research initiatives.[12–14] This emphasis on large-scale, cross-disciplinary initiatives neglects several important questions. For instance, what kinds of team science programs have been pursued outside of this context? What is known about unidisciplinary team science? How does unidisciplinary team science compare to other types of cross-disciplinary team science collaborations (e.g., multidisciplinary, interdisciplinary, or transdisciplinary research) in its efforts to effectively and efficiently solve complex health problems? What basic principles are transferable to cross-disciplinary science? What are the challenges that distinguish unidisciplinary team science from cross-disciplinary team science? What can be learned from smaller-scale, cross-disciplinary—and more specifically, transdisciplinary—initiatives?[15] For instance, could smaller team science endeavors have fewer infrastructure constraints or less "drag" and, hence, greater flexibility and sustainability—resulting in increased creativity and efficiency?[16,17] Furthermore, can terms be developed that capture all types of cross-disciplinary team science (including multidisciplinary, interdisciplinary, and transdisciplinary sole-investigator, as well as collabo-

rative, projects)? Is there a need to have different terms for team science that incorporate areas outside of academia, such as community-based participatory research or dissemination and implementation science?[8,18,a]

Team Science Readiness from a Social–Ecologic Perspective

Another important theme reflected in several articles in this supplement is the conceptualization and measurement of readiness for collaboration. This facet of team science has been conceptualized and measured in a variety of ways—for instance, in terms of individual and group research orientations, organizational and technologic resources that enhance the capacity for collaboration,[4,12,17] and the scientific readiness of different fields for collaborative integration.[11,21]

Stokols et al.[17] identified collaboration-readiness factors nested within a social–ecologic framework, including factors such as shifts in individuals' research orientations and their attitudes toward collaboration[12]; the availability of specific communication tools and cyberinfrastructural resources[22]; and funding agencies' willingness to invest in center-based, multiple-principal investigator grants.[10] In an increasingly globalized world, the demands for cross-national collaborations in health science, engineering, and technology will continue to grow. Also, as funding streams diminish, the need to coordinate and integrate health research efforts among academic institutions, government agencies, private corporations, and foundations will become increasingly important.[8,18,21,23] How can these sectors be brought together effectively and work toward the common goal of improving human health? What are the specific collaborative challenges inherent in collaborations that span multiple sectors?

Klein[1] in this supplement discussed the international scope of research on team science. The identification and implementation of the most effective strategies for enhancing global collaboration in the expanding domain of team science have yet to be further explored. Ensuring the success of transdisciplinary team science in the global arena requires an understanding of and sensitivity to cultural differences and their impact on teamwork.

The authors propose that future research explicitly consider multiple levels and dimensions of readiness for transdisciplinary team science, nesting certain levels within others and conducting in-depth case studies to identify which types of readiness factors (e.g., psychological, interpersonal, organizational, societal, technologic, scientific) exert the greatest influence on the effectiveness of team science projects and initiatives. A readiness framework can help generate appropriate multilevel interventions to increase the success of transdisciplinary team science. For instance, at the interpersonal level, understanding a team's readiness to engage in group processes to create common ground, common language, and shared goals can lead to the development of workshop modules to foster improved communications skills and team cohesiveness.[17] To date, evaluations of transdisciplinary initiatives have not given much attention to the relative impact of these diverse readiness factors on the effectiveness of team science, nor have they identified either the role that these readiness factors might have played in the successful implementation of an initiative or the ways in which multiple readiness factors jointly affect the processes and outcomes associated with transdisciplinary team science initiatives.

The Sustainability of Transdisciplinary Team Science

Critics of transdisciplinary team science, in addition to being concerned about the volume of funds directed toward transdisciplinary team science and away from unidisciplinary research, contend that once transdisciplinary-specific funding is removed from a research group, center, or institution, the earlier collaborative efforts will not be sustained.[24,25] To date, this contention has not been tested directly by evaluating whether transdisciplinary teams remain productive and cohesive once their original sources of funding are expended. Nonetheless, these critiques of team science initiatives raise important questions about the continuity of collaborative research ventures once they have been initiated and funded for a determinate period (usually 3–5 years, followed by a competitive review for renewal funding).

How can a new model of transdisciplinary science funding be created that can sustain team members' efforts to develop integrative conceptual models and methodologic approaches spanning multiple fields and extended periods of collaboration (e.g., extending 10–15 years or longer)? What happens if funding of the requisite long-term support for team science initiatives is not maintained—will transdisciplinary science stagnate? Might a lack of long-term funding commitments lead researchers to revert to more traditional small,

[a]As noted by Stokols et al.[2] and Trochim et al.,[19] large-scale transdisciplinary team science includes initiatives such as those that provide $5 million per center over the course of 5 years. These initiatives typically include 5–8 funded centers often networked through the efforts of NIH staff or a separate coordination center to facilitate cross-project and cross-center collaborations. Small-scale initiatives provide less funding and entail less formal (if any) coordination of cross-project and cross-team collaboration.

An example of a smaller-scale initiative is the Robert Wood Johnson Foundation's Active Living Research program,[20] which has accepted small-scale applications with amounts ranging from $25,000 for 1 year to $600,000 for 3 years. Total available award amounts ranged from $500,000 to $3.5 million in a given year over the first 7 years the program. Although the Active Living Research program provides some logistical support and a yearly conference to encourage knowledge sharing, these are primarily small grants being conducted by independent and dispersed transdisciplinary teams.

incremental, scientific development processes? Can substantial gains in cross-disciplinary integration and translations to health practice be achieved through small transdisciplinary science teams? Is small-scale transdisciplinary science more sustainable with respect to funding streams, or is large-scale transdisciplinary science needed to create a critical mass of researchers and infrastructure for the sustainability of transdisciplinary science? More specifically, are large, initiative-based transdisciplinary science centers needed to ensure sufficient levels of multidisciplinary expertise to propel collaborations—as well as theoretical and methodologic advances—in resolving the most urgent societal health problems? How can grant-review processes be redesigned to facilitate more rapid progress toward transdisciplinary integration and to accommodate and sustain the steadily increasing complexity of team science?[16,26] How can long-term partnerships be developed among government agencies, private industries, not-for-profit organizations, philanthropies, and foundations to ensure alternative but continuing support for cross-disciplinary team sciences?[18] What other institutional resources can be provided to encourage forward momentum and to establish long-range incentives for sustaining transdisciplinary team science?

Methods and measures to evaluate the sustainability of transdisciplinary team science are also crucial. In the context of the large transdisciplinary-center initiatives described in this supplement, evaluative strategies to assess the evidence of sustained productivity for centers that received first-round funding but were not renewed have yet to be implemented. In the context of funded research networks, advanced network analysis techniques might be considered to obtain comprehensive baseline assessments of research networks and to track these networks beyond their years of funding, assessing the degree to which a given network has retained or expanded its original set of investigators and the extent to which those investigators are representative of diverse disciplines. Moreover, assessments of a network's productivity—with respect to the extent that a network is integrative and adaptable—are likely to be critical to understanding its value-added contributions and sustainability as a team science endeavor. The evaluation of a network's productivity may include, for example, assessing the capacity of that network to successfully integrate multiple levels and diverse disciplinary knowledge to solve complex problems and to move into new areas of exploration as current problems are resolved.

In addition to resources for infrastructure and funding that stimulate and maintain team science, training is critical to the continuation of transdisciplinary team science research agendas. Without a focus on training the next generation of transdisciplinary researchers, the long-range sustainability of transdisciplinary team science is likely to be curtailed.

Training and Transformation: Developing Transdisciplinary Researchers

Transdisciplinary team science is still in the early phase of its development. Models to guide the development of transdisciplinary training curricula remain to be developed and tested. Nash[27] in this supplement summarizes various conceptual models for enhancing transdisciplinary training processes and outcomes that are associated primarily with advanced graduate student- and postdoctoral-level training. In addition to training pre- and post-doctoral scholars, providing transdisciplinary training opportunities for senior investigators is also important, as they are charged with mentoring as well as with greater management responsibilities within large research initiatives.[28,29] Broader models of transdisciplinary training that encompass the needs of all stakeholders including senior investigators, junior investigators, post-doctoral scholars, graduate students, and research support staff should be incorporated into the overall infrastructure of team science. Possible foci of these expanded transdisciplinary training programs include strategies for cultivating effective mentoring practices and leadership styles, interpersonal and managerial skills, communication strategies, technologic expertise, and coping strategies for information overload.[17]

Moreover, an important purpose of the training component of a transdisciplinary initiative is to develop the pool of emerging transdisciplinary scientists. So how are successful training processes and outcomes, and related circumstances for success, to be identified? What are the training elements that promote successful mentoring and training experiences from the perspectives of both trainees and mentors? Both retrospective and prospective evaluations of the processes and outcomes of transdisciplinary training at different stages of an initiative should be incorporated within future team science initiatives.

When considering the evaluation of transdisciplinary training, Nash[27] outlines some examples of the types of metrics and time frames that would be useful for capturing the quality, novelty, and scope of disciplinary integration of the work completed by a trainee over time. The development and application of reliable and valid metrics to assess these dimensions are sorely needed in the field. Quantitative and qualitative assessments of the career trajectories of trainees in various transdisciplinary science training programs can provide a deeper understanding of the impact of different training models and the ways in which transdisciplinary trainees gain entry to various academic, government, and private-sector positions, as well as whether their transdisciplinary training leads to sustained transdisciplinary research efforts as they move forward with their careers. For example, the assessment of trainees' evolving research orientations over time can be used to model and subsequently predict the relevant long-term

career outcomes of these individuals.[12,27,28] Systematically tracking the career development trajectory of transdisciplinary trainees over time and examining the influence of earlier transdisciplinary training on their subsequent productivity will ultimately help to gauge the "returns" on team science investments at both individual and societal levels.[28]

Team Science Models and Methods

Several conceptual frameworks were presented in this supplement to describe and evaluate the processes of transdisciplinary team science.[1,12,14,21,30,31] A major focus of these models has been on understanding the factors that facilitate or constrain transdisciplinary team science collaboration. The models have been drawn from a variety of fields, such as sociology, ecology, physics, and applied mathematics. Examples of the models currently used to describe transdisciplinary team science include the social–ecologic model,[16] systems thinking and complexity theory,[18] network analysis,[27] a social-determinants paradigm,[26] and the heterarchical analytic framework.[3] These models have been used as programmatic frameworks for describing, organizing, and evaluating team science. Additionally, efforts have been focused on an integrated transdisciplinary conceptual framework for understanding and solving a problem at the early stage of team initiatives. Examples of such efforts have been documented through transdisciplinary research initiatives funded by both private and public funders.[32,33]

To date, important intellectual integration and scientific breakthroughs have been achieved within transdisciplinary team science initiatives by focusing on methodologic advances.[14] New transdisciplinary measures are showcased in the supplement.[12,14,31] With a limited number of metrics available, many authors called for new evaluative criteria to be developed—to assess, for example, recently proposed models of transdisciplinary leadership and training[27,34] and to identify valid short-term scientific outcomes.[35] Furthermore, innovative research design strategies need to be utilized and refined to overcome the remaining methodologic challenges, such as identifying appropriate comparison groups in the evaluation of transdisciplinary initiatives.[35] The creative use of existing methods should be encouraged, such as utilizing network analyses to more clearly integrate theoretical constructs of team science models and link them to relevant outcomes. Strategies such as bibliometric analysis and mapping the productivity of a transdisciplinary initiative to the overall landscape of scientific productivity of a field (e.g., tobacco-control research) are currently in progress at the NIH. Utilizing rigorous comparison-group designs, such bibliometric studies also can be used to identify similarities and differences in the quantity and quality of research productivity in both transdisciplinary science and traditional, individually-oriented research efforts. Key goals of these studies are to calibrate the potential value-added contributions of transdisciplinary science and to enable a better understanding of how supportive orientations toward transdisciplinary science (e.g., at the levels of individual investigators, research organizations, and funding agencies) influence scientific productivity and the effectiveness of health policies in the long run.

As more research in the area of interdisciplinary and transdisciplinary research and training is funded, there will be a growing need and opportunity for evaluating transdisciplinary team science. In addition to the systematic development and testing of methods and models, both infrastructure and support should be devoted to enabling such evaluations, which should include both internal and external evaluations of research programs and initiatives. The expansion of the Office of Portfolio Analysis and Strategic Initiatives at NIH continues to provide the opportunity for using internal funds to evaluate NIH-funded activities—a forward stride in building the capacity for evaluating and studying team science within the funding agency. Innovative funding mechanisms for supporting the evaluation of transdisciplinary team science collaborations should continue to be developed. Accordingly, budgetary allocations for evaluation activities are included currently in some funding mechanisms for large initiatives (e.g., the Transdisciplinary Research on Energetics and Cancer [TREC] initiative) that enables a coordination center to lead evaluation activities.[12] Separate or more clearly dedicated funding streams for transdisciplinary program evaluation, per se, would further support the design and implementation of comprehensive transdisciplinary science evaluation studies.[10,19]

Forging New Transdisciplinary Partnerships Across Sectors

An important direction for the science of team science is to examine factors that facilitate or impede productive partnerships among the multiple sectors of society that share an interest in sustaining transdisciplinary research, training, knowledge translation, and dissemination for the purpose of improving public health. As federal and state funding allocations for health research are reduced by societal demands for nonhealth-related investments (e.g., maintaining homeland security, enhancing access to higher education among low-income and minority groups), the development of creative and productive partnerships among universities, government agencies, NGOs, private foundations, and corporations aimed at cultivating and sustaining public health research will become an increasingly important task. Along those lines, a better understanding is needed of the circumstances under which public and private organizations are most likely to partner

effectively to achieve shared public health goals. Gruman and Prager[36] outline examples of facilitators of effective partnerships among public research agencies (such as NIH) and philanthropic organizations (such as private health foundations); more work should be done to utilize and expand these efforts.

Also, Shen[18] in this supplement identifies conditions under which private corporations interested in commercializing health-related products might partner effectively with public funding agencies. At the same time, however, more needs to be learned about the key facilitators and constraints on effective public–private partnerships aimed at promoting improved health practices, products, and outcomes. For instance, it will be important to develop strategies for removing barriers that sometimes arise when corporate and public entities make efforts to collaborate. Examples of these barriers include scientists' concerns that their work will be distorted or tainted by market pressures as well as the profitability interests of companies contributing funding for the research, and corporate concerns that much scholarly research is impractical, unusable, and produced at a too-slow pace unsuitable for translation to commercialized health products or to improved health practices.

Conclusion

Moving Forward with Creativity

As described above, the science of team science is faced with many challenges yet to be solved. How are the value-added contributions of transdisciplinary science best assessed? When is transdisciplinary science warranted and when it is not, and how is that best decided? How can transdisciplinary science be conducted in a "smarter" manner? These questions ultimately lead to other concerns about the fundamental structure and culture in which science is conducted today and to demands for solutions that are driven by creativity. Current award mechanisms must be more creatively assessed, along with their strengths and weaknesses, with an understanding of the circumstances that indicate when an award works or does not work; new mechanisms to match current needs must be developed; more flexible infrastructures created; and a diverse array of institutionalized award mechanisms (such as the NIH P50 and U52 grants)[37] institutionalized—all of which can be used to foster the development of innovative transdisciplinary frameworks and methodologies for research development, dissemination, and practice. Examples of such initiatives, the Transdisciplinary Tobacco Use Research Centers—funded by NIH—include: the Centers for Population Health and Health Disparities, the Centers of Excellence in Cancer Communication Research, and TREC.[10,12–14] Additionally, the Clinical Translational Science Centers recently established by the National Center for Research Resources via the NIH Roadmap to promote the translation and dissemination of research findings through innovative partnerships among health scientists, practitioners, and community decision makers.[38]

The field needs to overcome the barriers between the scientific research community and the utilization-oriented private corporations to empower all stakeholders, scientists, funders, policymakers, patients, and physicians—to name but a few—in identifying urgent problems and setting research agendas and priorities for the ultimate benefit of the nation.[18,36] Also needed is a culture that promotes appreciation and recognition of team science and that rewards team effort and contributions, nurturing a value system that encourages equitable research arrangements and collective leadership/authorship models.[34,39] Further, the scientific community can contribute to an appreciation of team effort and team contributions by creating new cross-disciplinary journals and new criteria for tenure and promotion. Also to be engaged are higher education accreditation organizations, journal editors, review boards, funding agencies, scientists, university presidents, and deans in promoting and sustaining innovative and collaborative partnerships among health scientists, community practitioners, and policymakers.

As an increasing amount of funding has been allocated for transdisciplinary team science, especially during times of constrained budgets, critics have argued that transdisciplinary initiatives take precious resources away from more productive sole-investigator (and typically unidisciplinary) work.[17,24,25] Systematic and rigorous studies of the scientific and societal health impacts of different funding mechanisms are warranted for the next steps of team science development. The science of team science can be advanced through systematic assessments and a strong research agenda. But, more importantly, a creative approach is needed to cultivate a broader culture of integrated, heterarchical scientific inquiry.[30] Boundaries must be pushed not only by the development of new scientific models, methods, and measures, but also by the initiation of organizational innovations that create fundamental changes in the ways scientists do business—changes that embrace multiple disciplines, sectors, and cultures; revolutionize award mechanisms, funding streams, and publications; and allow flexibility and fluidity to eliminate the constraints of rigid hierarchic structures[30]—to release talent bound by towers of tradition into a sea of creativity. A new era of creativity and innovation in transdisciplinary science can be achieved through simultaneous and coordinated efforts that remove collaborative barriers and build new linkages across multiple sectors of society and across spheres of research. In this new era of creativity and innovation in transdisciplinary research, current scientific research paradigms and infra-

structures will be transformed in ways that enable the world's scientists to leverage global resources to resolve the most pressing environmental and public health problems of the 21st Century.

No financial disclosures were reported by the authors of this paper.

References

1. Klein JT. Evaluation of interdisciplinary and transdisciplinary research: a literature review. Am J Prev Med 2008;35(2S):S116–S123.
2. Stokols D, Hall KL, Taylor BK, Moser RP. The science of team science: overview of the field and introduction to the supplement. Am J Prev Med 2008;35(2S):S77–S89.
3. National Cancer Institute. Proceedings of the NCI–NIH Conference on The Science of Team Science: Assessing the Value of Transdisciplinary Research. 2006 Oct 30–31; Bethesda MD. videocast.nih.gov/Summary.asp?File=13474; videocast.nih.gov/Summary.asp?File=13471.
4. Kessel FS, Rosenfield PL, Anderson NB, eds. Interdisciplinary research: case studies from health and social science. New York: Oxford University Press, 2008.
5. Rosenfield PL. The potential of transdisciplinary research for sustaining and extending linkages between the health and social sciences. Soc Sci Med 1992;35:1343–57.
6. Farber G. An overview of the NIH Roadmap initiative. Proceedings of the NCI–NIH Conference on The Science of Team Science: Assessing the Value of Transdisciplinary Research. 2006 Oct 30–31; Bethesda MD. videocast.nih.gov/Summary.asp?File=13474.
7. NIH. NIH Roadmap for medical research: interdisciplinary research. 2003. nihroadmap.nih.gov/interdisciplinary/index.asp.
8. Stokols D. Toward a science of transdisciplinary action research. Am J Community Psychol 2006;38:63–77.
9. Aronoff NL, Bailey D. Social work practice guidelines in an interprofessional world: honoring new ties that bind. In: Rosen AK, Proctor EK, eds. Developing practice guidelines for social work interventions. New York: Columbia University Press, 2003.
10. Croyle RT. The National Cancer Institute's transdisciplinary centers initiatives and the need for building a science of team science. Am J Prev Med 2008;35(2S):S90–S93.
11. Hays TC. The science of team science: commentary on measurements of scientific readiness. Am J Prev Med 2008;35(2S):S193–S195.
12. Hall KL, Stokols D, Moser RP, et al. The collaboration readiness of transdisciplinary research teams and centers: findings from the National Cancer Institute's TREC year-one evaluation study. Am J Prev Med 2008;35(2S):S161–S172.
13. Holmes JH, Lehman A, Hade E, et al. Challenges for multilevel health disparities research in a transdisciplinary environment. Am J Prev Med 2008:35(2S):S182–S192.
14. Mâsse LC, Moser RP, Stokols D, et al. Measuring collaboration and transdisciplinary integration in team science. Am J Prev Med 2008; 35(2S):S151–S160.
15. Sallis J, Oberholtzer C, Mitrany M. Lessons learned-developing new strategies for strengthening transdisciplinary science and training initiatives. Proceedings of the NCI-NIH Conference on The Science of Team Science: Assessing the Value of Transdisciplinary Research. 2006 Oct 30-31; Bethesda MD. videocast.nih.gov/Summary.asp?File=13471.
16. Stokols D, Harvey R, Gress J, Fuqua J, Phillips K. In vivo studies of transdisciplinary scientific collaboration: lessons learned and implications for active living research. Am J Prev Med 2005;28(2S2):202–13.
17. Stokols D, Misra S, Moser RP, Hall KL, Taylor BK. The ecology of team science: understanding contextual influences on transdisciplinary collaboration. Am J Prev Med 2008;35(2S):S96–S115.
18. Shen B. Toward cross-sectoral team science. Am J Prev Med 2008; 35(2S):S240–S242.
19. Trochim WM, Marcus SE, Mâsse LC, Moser RP, Weld PC. The evaluation of large research initiatives: a participatory integrated mixed-methods approach. Am J Eval 2008;29:8–28.
20. Robert Wood Johnson Foundation. Active living research. 2008. www.activelivingresearch.org/.
21. Leischow SJ, Best A, Trochim WM, et al. Systems thinking to improve the public's health. Am J Prev Med 2008;35(2S):S196–S203.
22. Hesse BW. Of mice and mentors: developing cyber-infrastructure to support transdisciplinary scientific collaboration. Am J Prev Med 2008; 35(2S):S235–S239.
23. Syme SL. The science of team science: assessing the value of transdisciplinary research. Am J Prev Med 2008;35(2S):S94–S95.
24. Marks AR. Rescuing the NIH before it is too late. J Clin Invest 2006; 116:844.
25. Weissmann G. Roadmaps, translational research, and childish curiosity. FASEB J 2005;19:1761–2.
26. Morgan G, Kobus K, Gerlach KK, et al. Facilitating transdisciplinary research: the experience of the transdisciplinary tobacco use research centers. Nicotine Tob Res 2003;5(1S):S11–S19.
27. Nash JM. Transdisciplinary training: key components and prerequisites for success. Am J Prev Med 2008;35(2S):S133–S140.
28. Mitrany M, Stokols D. Gauging the transdisciplinary qualities and outcomes of doctoral training programs. J Plann Educ Res 2005;24:437–49.
29. Rhoten D, Parker A. Education: risks and rewards of an interdisciplinary research path. Science 2004;306:2046.
30. Kessel FS, Rosenfield PL. Toward transdisciplinary research: historical and contemporary perspectives. Am J Prev Med 2008;35(2S):S225–S234.
31. Provan KG, Clark P, Huerta T. Transdisciplinarity among tobacco harm–reduction researchers: a network analytic approach. Am J Prev Med 2008;35(2S):S173–S181.
32. Clayton RR, Merikangas KR, Abrams DB. Tobacco etiology research network (TERN) grantresults.2000.www.rwjf.org/programareas/resources/grantsreport.jsp?filename=tern.htm&pid=1141&gsa=5.
33. Kahn RL. An experiment in scientific organization. Chicago IL: The John D. and Catherine T. MacArthur Foundation, Program in Mental Health and Human Development. A MacArthur Foundation Occasional Paper; 1993. http://www.macfound.org/atf/cf/%7BB0386CE3-8B29-4162-8098-E466FB856794%7D/experiment_in_scientific_organization.pdf.
34. Gray B. Enhancing transdisciplinary research through collaborative leadership. Am J Prev Med 2008;35(2S):S124–S132.
35. Moser RP, Gladden M, Ames M, Porter D, Marcus S. Reflections on new concepts and methods for evaluating transdisciplinary research and training. Proceedings of the NCI-NIH Conference on The Science of Team Science: Assessing the Value of Transdisciplinary Research. 2006 Oct 30–31; Bethesda MD. videocast.nih.gov/Summary.asp?File=13471.
36. Gruman J, Prager D. Health research philanthropy in a time of plenty: a strategic agenda. Health Aff 2002;21:265–9.
37. NIH. Types of grant programs. 2008. grants.nih.gov/grants/funding/funding_program.htm.
38. National Center for Research Resources. Clinical and translational science awards to transform clinical research. 2006. www.ncrr.nih.gov/ncrrprog/roadmap/CTSA_9-2006.asp.
39. Altman DG. Sustaining interventions in community systems: on the relationship between researchers and communities. Health Psych 1995; 14:526–36.