Can't We All Get Along?

The Art and Science of Transdisciplinary Team Science

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Overview

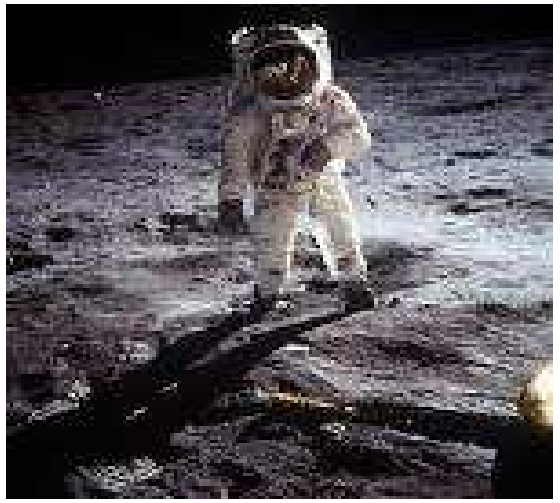
1. *Growing interest and investment in team science-core concerns of the science of team science*

2. *Methods and tools to enable the study and enhance the practice of team science*

3. *Research findings from studies of NIH transdisciplinary research and training centers*

4. *Practical implications and future directions*

The Emergence of Team Science



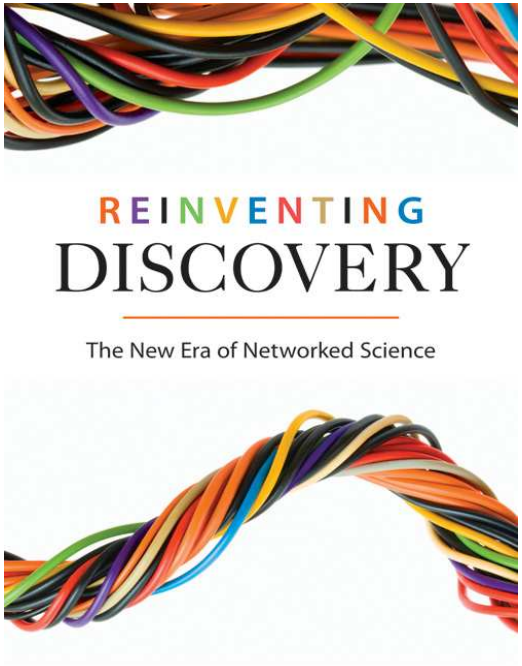
(See Wuchty, S., B. F. Jones, et al. (2007, *Science*). "The increasing dominance of teams in production of knowledge.")

Rapid Growth and Increasing Dominance of Team Science Over Past Several Decades and Across Multiple Fields

According Wuchty et al., Science, 2007:

- 19.9 million papers over 5 decades and 2.1 million patents
- Research is increasingly done in teams across nearly all fields
- Teams typically produce more frequently cited research than individuals (this has been increasing over time)
- Teams now also produce the exceptionally high impact research even where that distinction was once the domain of solo authors
- These trends are consistent across the physical and biological sciences, engineering, social sciences, arts and humanities

Collective Intelligence



Google

Substantial Investments in Team Science Initiatives Have Been Made Over the Past Three Decades

- NIH Roadmap Initiative, and Clinical and Translational Science Centers (2003-present)

- MacArthur Foundation Networks in Mental Health and Human Development (1980-present)

- Robert Wood Johnson Foundation- Active Living Research Program (2002-present)

- NAS-Keck Foundation Initiative to Transform Interdisciplinary Research (2003-present)

THERAPEUTICS

US translational-science centre gets under way

Mission of newly formed NCATS is to dramatically speed up production of drugs and other therapies, but sceptics question agency's ability to deliver.

BY MEREDITH WADMAN

Scarcely a year after plans to establish it were made public, the National Center for Advancing Translational Sciences (NCATS), the newest branch of the US National Institutes of Health (NIH) in Bethesda, Maryland, is up and running. On 4 January the centre's 230 employees gathered for their first 'all-hands' meeting, at which they heard an exhortation from NIH director Francis Collins and his lieutenants about the importance of the centre's mission: finding ways to radically speed up the development of new drugs, devices and diagnostics.

"Patients suffering from debilitating and life threatening diseases do not have the luxury to wait the 13 years it currently takes to translate new scientific discoveries into treatments," Collins said on 23 December, the day President Barack Obama signed the law creating NCATS. Congress had for months expressed concerns that NCATS could infringe on the private sector, and that the NIH was rushing it into existence. But the critics relented, and Congress approved the US$576-million centre on 17 December as part of a massive government funding bill.

"Getting drugs that work in people is a very hard thing to do."

The law creates NCATS from several existing NIH programmes — most notably, the Clinical and Translational Science Awards (CTSA; see table). In the new law, Congress directs the NIH to spend at least $488 million on the awards in 2012. At the same time, it dissolves the National Center for Research Resources (NCRR), where the CTSA programme has been housed, and parcels out that centre's programmes to other parts of the NIH. NCATS will also administer a Cures Acceleration Network (CAN), authorized in the 2010 health-reform law and now funded for the first time under the new law. CAN, a competitive grant programme that will allow the agency to circumvent bureaucratic obstacles and push promising drugs forward, received just $10 million, one-tenth of what Collins had requested. The minimal funding nonetheless means that the programme "can get up and running", says Margaret Anderson, executive director of FasterCures, a think tank in Washington DC that actively supported the creation of NCATS.

ASSEMBLING THE PUZZLE

NCATS will be created from pre-existing NIH programmes. Their budgets give a sense of their relative scale.

Programme	Original NIH home	Funding in 2011
Clinical and Translational Science Awards	National Center for Research Resources (NCRR)	$460.5 million (from NCRR); $22.7 million (from NIH Common Fund*)
Components of the Molecular Libraries Program	National Human Genome Research Institute (NHGRI)	$21.4 million (from Common Fund)
Therapeutics for Rare and Neglected Diseases	NHGRI	$24 million (from all NIH institutes and centres)
Bridging Interventional Development Gaps (formerly called RAID)	NHGRI	$15 million (from Common Fund)
Office of Rare Diseases Research	Office of the director	$17.8 million
NIH–FDA Regulatory Science Initiative	Office of the director	$2.7 million (from Common Fund)
Cures Acceleration Network	New	$0 ($10 million for 2012)

*The NIH Common Fund is a discretionary fund for short-term, trans-institute programmes, administered through the office of the director.

But the new centre has its sceptics — some of whom have voted with their feet. At the NCRR, 26 employees left during 2011 while Congress was debating their centre's future — more than twice the turnover in 2010. The dismantling "was a complete shock and surprise", says Barbara Alving, the former NCRR director, who resigned in September.

Others say that Collins is naive to suggest that the NIH can fix bottlenecks in the drug pipeline when the far-better-funded pharmaceutical industry has failed to do so. Creating NCATS "is sort of like declaring the war on cancer", says one critic. "Now what? Getting drugs that work in people is a very hard thing to do." But Congress wants NCATS to steer clear of industry prerogatives anyway: the legislation establishing it pointedly insists that the centre should "not create duplication, redundancy and competition with industry activities". And Congress explicitly forbids it from sponsoring late-stage clinical trials.

In a separate report, Congress instructs NCATS to protect both the money and the mission of the CTSA programme, which funds recipients at 60 academic medical centres nationwide — even though the recipients' activities do not always overlap with the new centre's mission. The CTSA programme would comprise at least 80% of the NCATS budget. Lawmakers have instructed the agency to enlist the Institute of Medicine to assess the CTSA's current mission, and to decide within 18 months whether changes are needed. Mark Lively, a biochemist at Wake Forest Baptist Medical Center in Winston-Salem, North Carolina, who served on the NCRR external advisory council, worries that, in the interim, NIH leaders will boost the rest of NCATS's budget by dipping into basic-science funding. NIH officials insist that this will not happen.

Meanwhile, at the top of the new centre's to-do list is finding a director. "We are thrilled with the applicants and are going to start interviews this month," says Kathy Hudson, acting deputy director of NCATS. ■

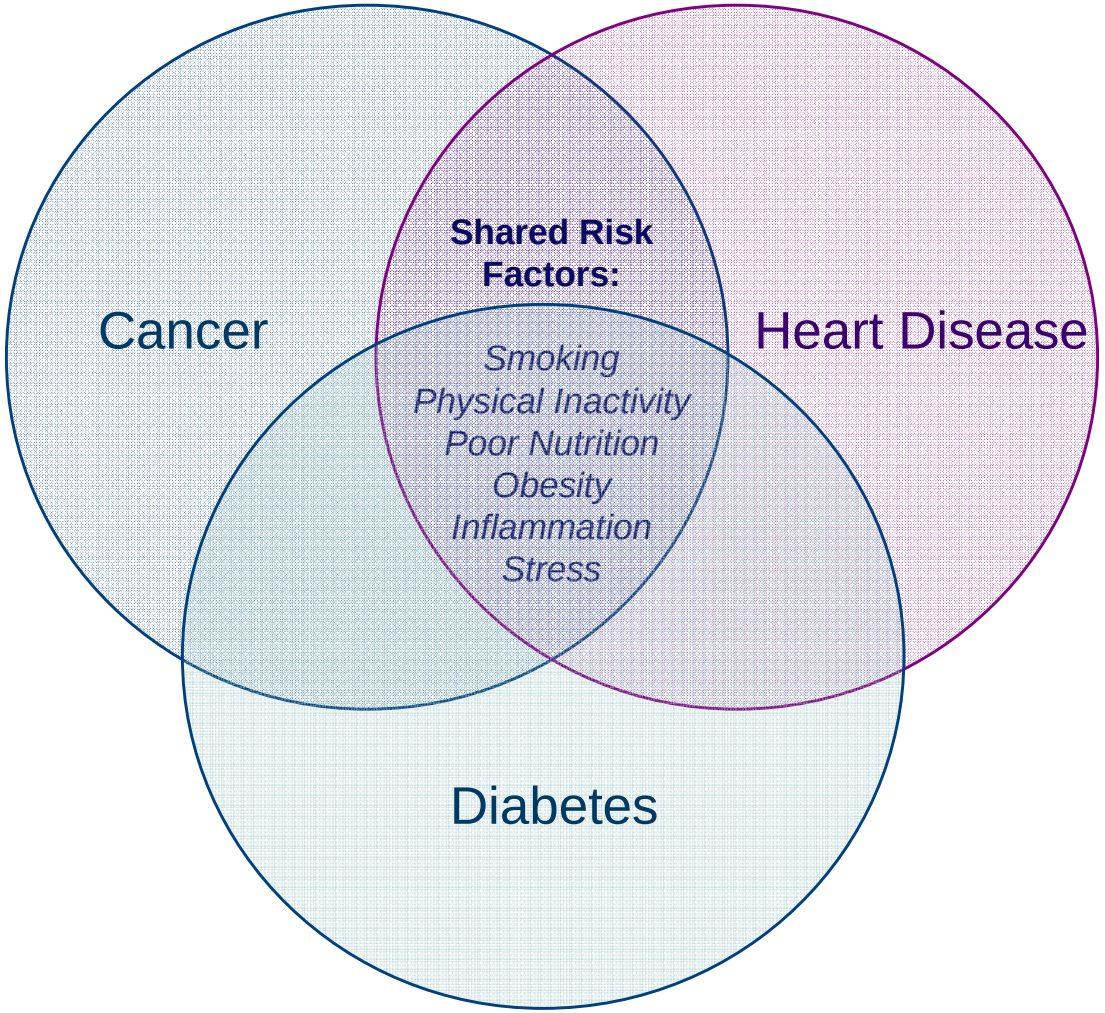
CLARIFICATION

The News story 'Last-minute wins for US science' (*Nature* **480**, 423; 2011) implied that the total US contribution to the Global Fund to Fight AIDS, Tuberculosis and Malaria is $298 million. This is just how much the National Institutes of Health was set to provide in 2012, and which will now be given instead by the Department of State.

CORRECTION

The News story '2011 in review' (*Nature* **480**, 426–429; 2011) confused its melanoma treatments: 'ipilimumab' should read 'vemurafenib'.

Toward Interdisciplinary Analyses of the Links Between Cancer, Heart Disease, and ~~Diabetes~~



Point-Counterpoint

The New York Times | International Herald Tribune
SundayReview | The Opinion Pages

OPINION

The Rise of the New Groupthink

By SUSAN CAIN
Published: January 13, 2012

SOLITUDE is out of fashion. Our companies, our schools and our culture are in thrall to an idea I call the New Groupthink, which holds that creativity and achievement come from an oddly gregarious place. Most of us now work in teams, in offices without walls, for managers who prize people skills above all. Lone geniuses are out. Collaboration is in.

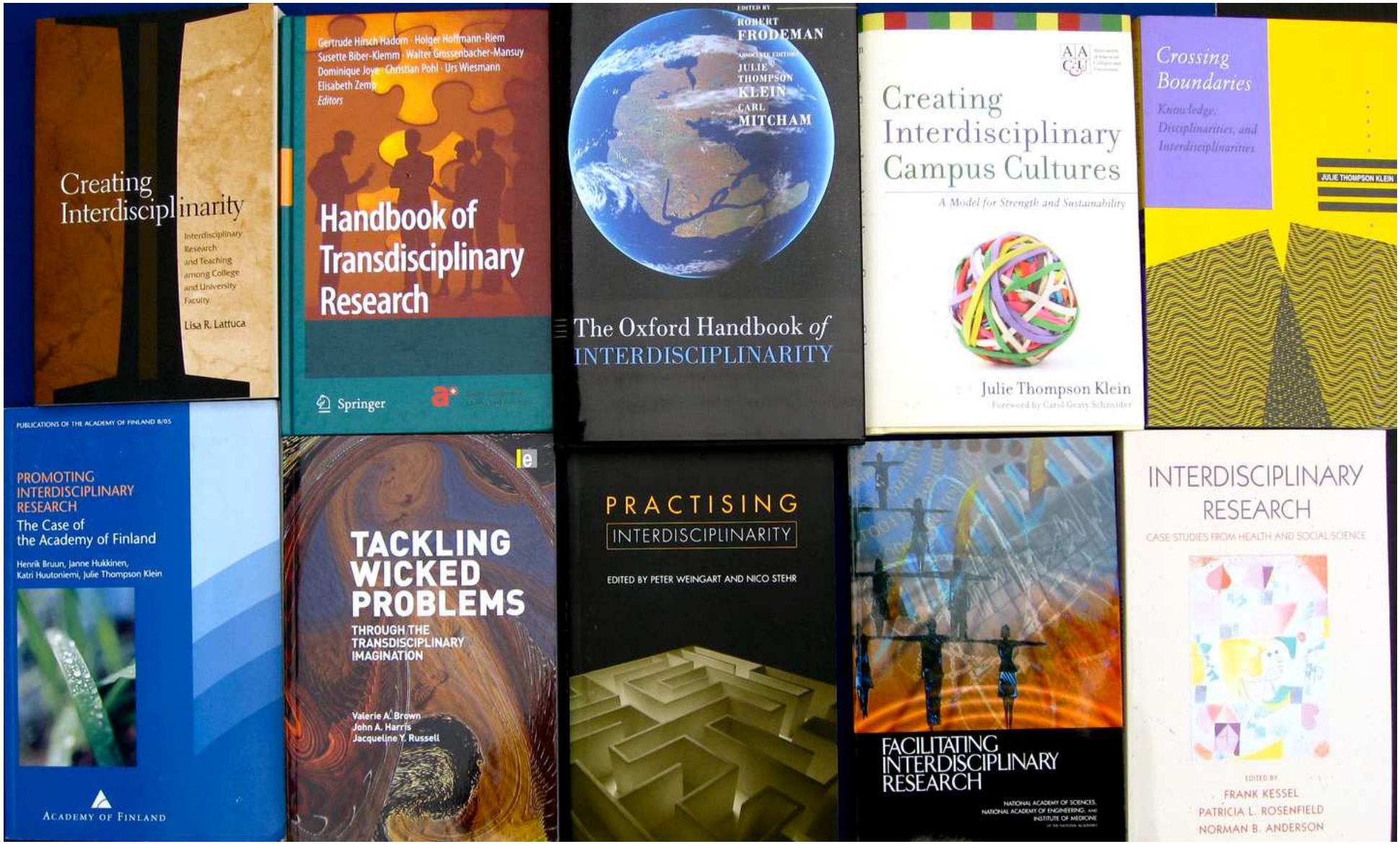
The New York Times January 15, 2012

Andy Rementer

The New York Times January 15, 2012

Andy Rementer

Burgeoning Interest and Investment in Studying and Facilitating Cross-Disciplinary Collaboration



The Science of Team Science

…a rapidly emerging field concerned with understanding and managing circumstances that facilitate or hinder the effectiveness of collaborative (and often cross-disciplinary) research, training, and translational initiatives

http://www.scienceofteamscience.org

Conceptualizing Uni-Disciplinary and Cross-Disciplinary Research

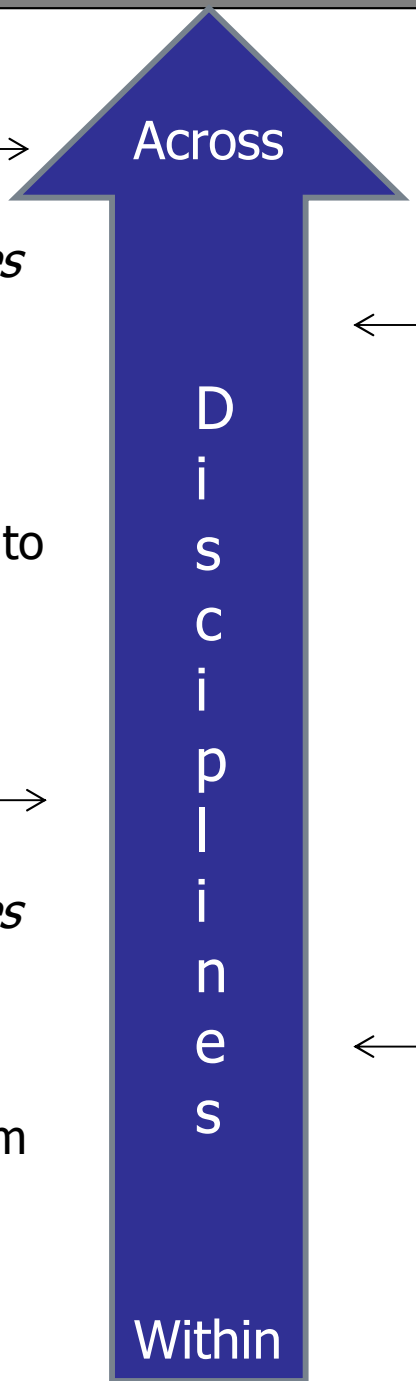
Academic Disciplines

Areas of research that focus on distinctive substantive concerns *(e.g., biological, behavioral, psychological, social, physical environmental facts)* and emphasize particular analytic levels *(e.g., nano, molecular, organismic, interpersonal, organizational, societal)*, concepts, and methods. Examples are psychology, sociology, geology, chemistry, physics, and biology.

Academic and Professional Fields

Fields of inquiry and practice encompass multiple disciplinary perspectives that are deemed relevant for understanding a particular research question or societal problem. Examples of fields spanning multiple disciplinary perspectives include public health, public policy, urban planning, sustainability sciences, and social ecology.

A Continuum of Cross-Disciplinary Integration



(Adapted from Rosenfield, 1992)

Transdisciplinary

Researchers from *different disciplines work jointly* to develop and use a shared conceptual framework that synthesizes and extends discipline-specific theories, concepts, and methods, to create new approaches to address a common problem

Multidisciplinary

Researchers from *different disciplines work sequentially,* each from their own discipline-specific perspective, with a goal of eventually combining results to address a common problem

Interdisciplinary

Researchers from *different disciplines work jointly* to address a common problem. Some integration of perspectives occurs, but contributions remain anchored in their own disciplines.

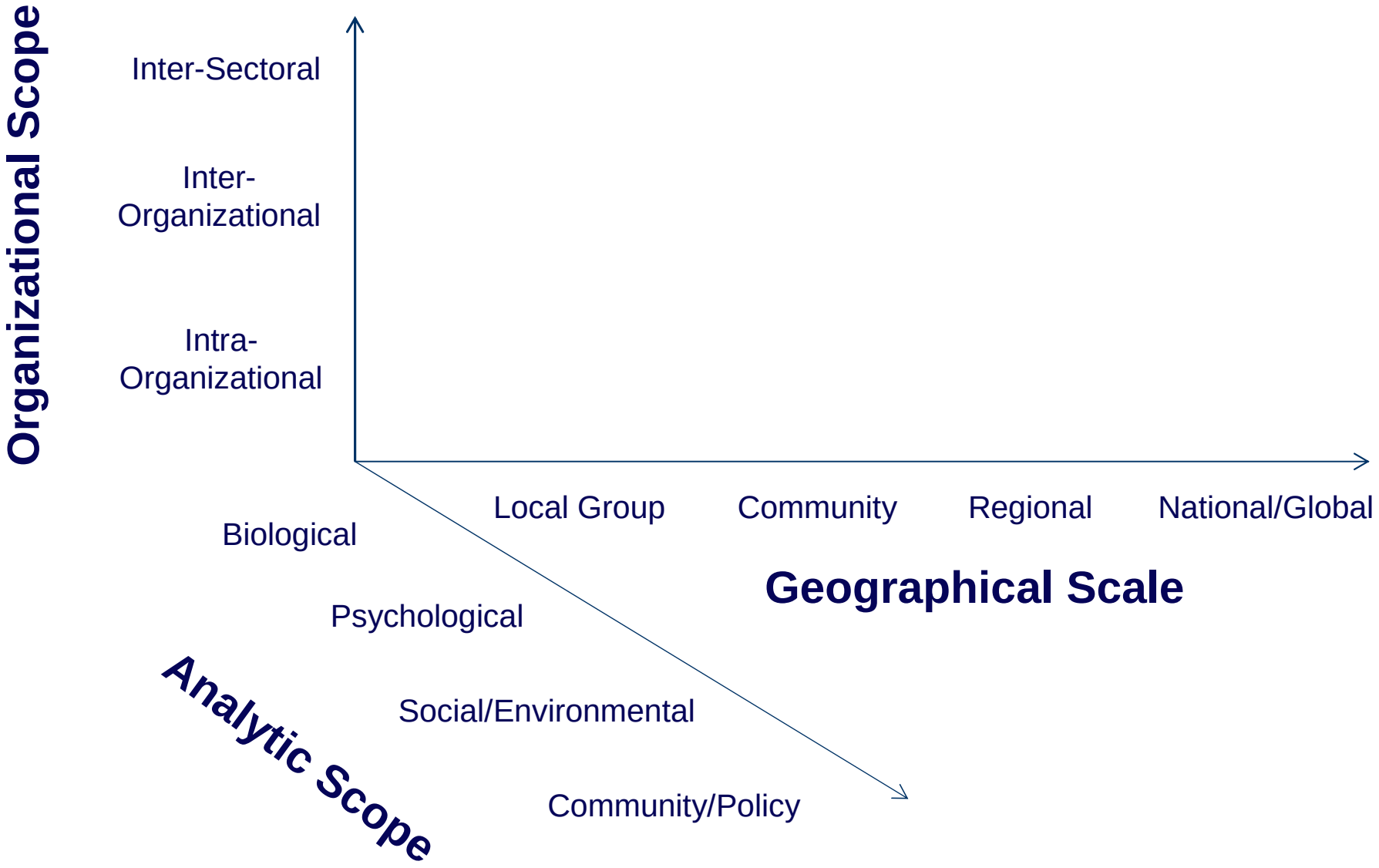
Unidisciplinary

Researchers from a *single discipline* work together to address a common problem

Translational Research and Practice

A sub-type of transdisciplinarity in which at least one academic discipline and one non-academic epistemology are integrated for purposes of creating novel approaches to analyzing and resolving complex community and societal problems; sometimes referred to as 'transdisciplinary action research'

Organizational, Geographic, and Analytic Scope of Transdisciplinary Research



(Stokols, 2006)

Academic and Non-Academic Perspectives

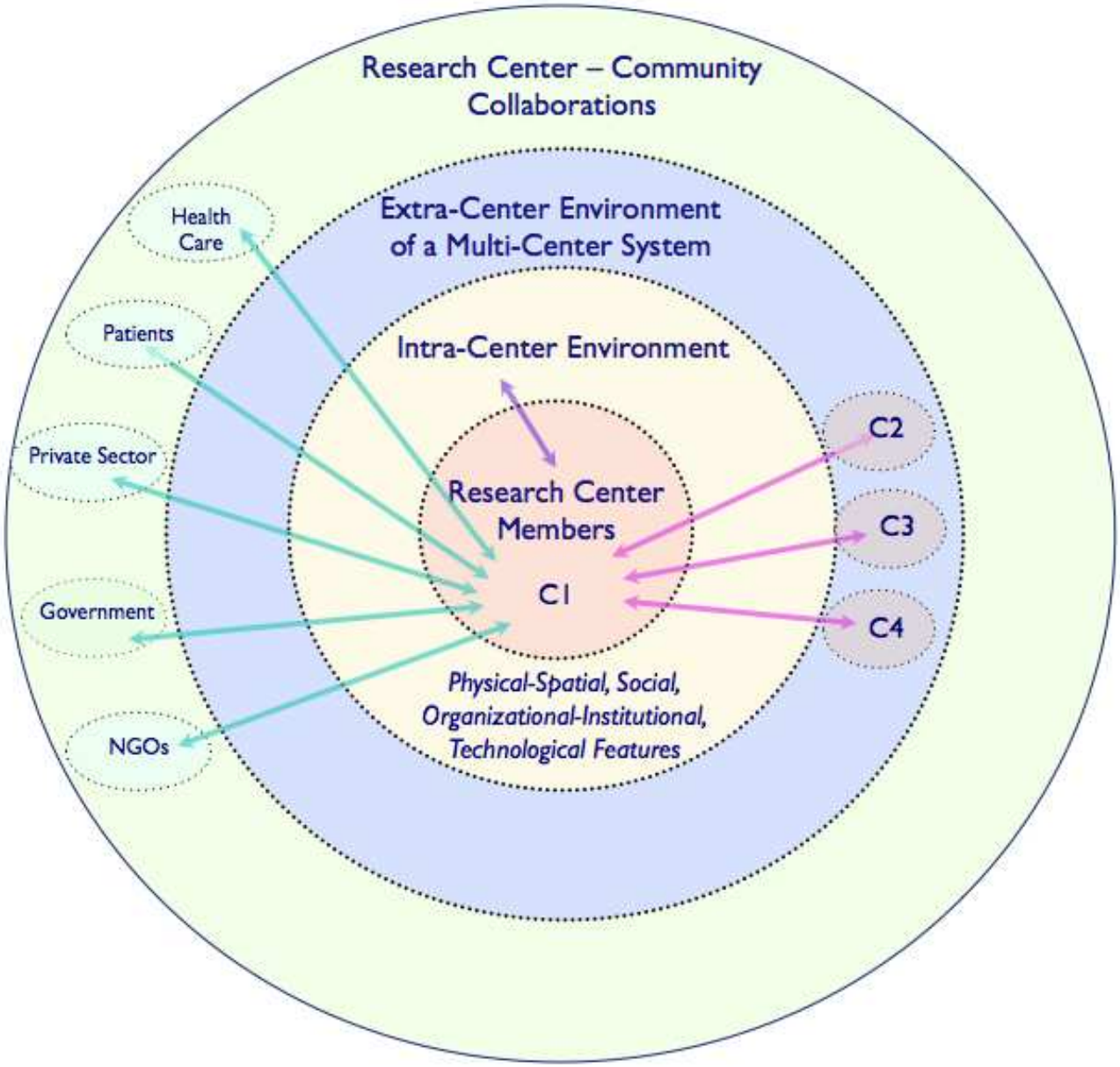
Scientists/Academicians– *discipline-centric and cross-disciplinary knowledge derived from theoretical analyses and empirical research*

Lay Citizens and Community Stakeholder Groups– *based on personal lifestyles, shared interests, subjective experiences, families, and other community groups*

Business Leaders and Other Professional Groups– *rooted in the experiences of businesses and financial institutions, and professional training in practice-oriented fields (e.g., accounting, finance, corporate law)*

Government Decision-Makers– *rooted in institutional governance, political realities, market dynamics, policy and planning strategies*

Arenas of TD Training for Translational Team Science



(Stokols, 2012)

Methods and Tools for Strategic Team Science

Methods and Tools

- *to enable the study of team science*

  (including logic models of the relationships between antecedent factors, emergent processes, and outcomes in team science; methods and metrics to evaluate those relationships)

- *to enhance the practice of team science*

  (including team science guidebooks, toolkits, and training modules; philosophical dialogue and collaboration readiness audits)

Strategic Team Science

Maximize cross-disciplinary integration and innovation while minimizing the costs incurred through scientific and translational collaboration.

Alternative Infrastructures for Promoting Team Science

Duration

Place Dependence	Shorter-Term	Longer-Term
Lower	• RWJF Active Living Research Teams • MacArthur Research Networks • National Academies Keck Futures Initiative conferences and seed grants	• Virtual collaboratories such as the "triple helix" Social Pharmacy and Pharmaco Epidemiology Group in the Netherlands; the NSF National Virtual Observatory; The Large Hadron Collider Collaborations supported by the European Center for Nuclear Research (CERN)
Higher	• NCI Transdisciplinary Research and Training Centers (TTURC, TREC, CPHHD, CECCR) • NCATS Clinical and Translational Science Awards • NIAID Centers of Excellence for Biodefense and Emerging Infectious Diseases	• Institute for Social Research, U. Michigan • Bond Life Sciences Center, U. Missouri • Santa Fe Institute, New Mexico • Ctr. for Adv. Study in Behav. Sciences, Stanford • Socio Envtl. Synthesis Center, U. Maryland • J. Craig Venter Institute, San Diego • RAND Corporation, Los Angeles • School of Social Ecology, UC Irvine • Arizona State University • NSF, NIH, NAS, CDC, TD-Net, RWJF, Keck

(these vary according to their *place-based* or *virtual qualities*, *size and duration of research programs*, *numbers of scientists participating*, *cross-disciplinary scope of the research undertaken*)

Costs Arising from Mis-Matches Between Research Infrastructures and Participants'Goals

- *Behavioral – fragmentation of scientists' research activities*
- *Cognitive – information overload arising from participation in complex collaborative transactions and multiple collaborative spheres*
- *Social – interpersonal conflict and strains arising from divergent scientific world views and disciplinary biases*
- *Organizational/Institutional – "sunk costs" invested in complex research infrastructures whose duration and sustainability are unclear*
- *Scientific/Community/Societal –investments of scarce resources for scientific research in"low-yield" initiatives; missed disciplinary or cross-disciplinary discoveries*

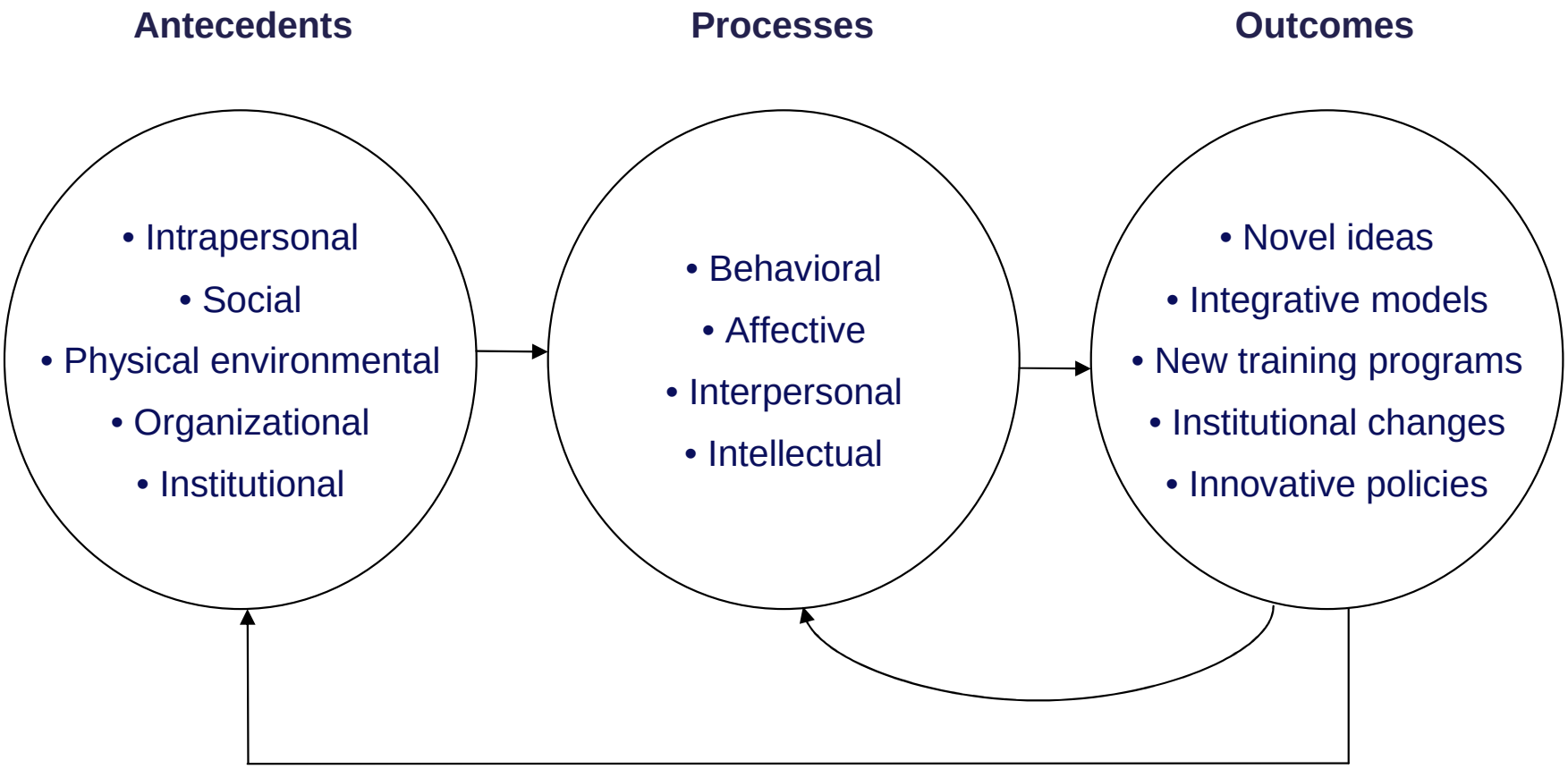
Studies of Large-scale TD Research Centers: Methods, Findings, and Lessons Learned

Features of Large Cross-Disciplinary Research and Training Initiatives

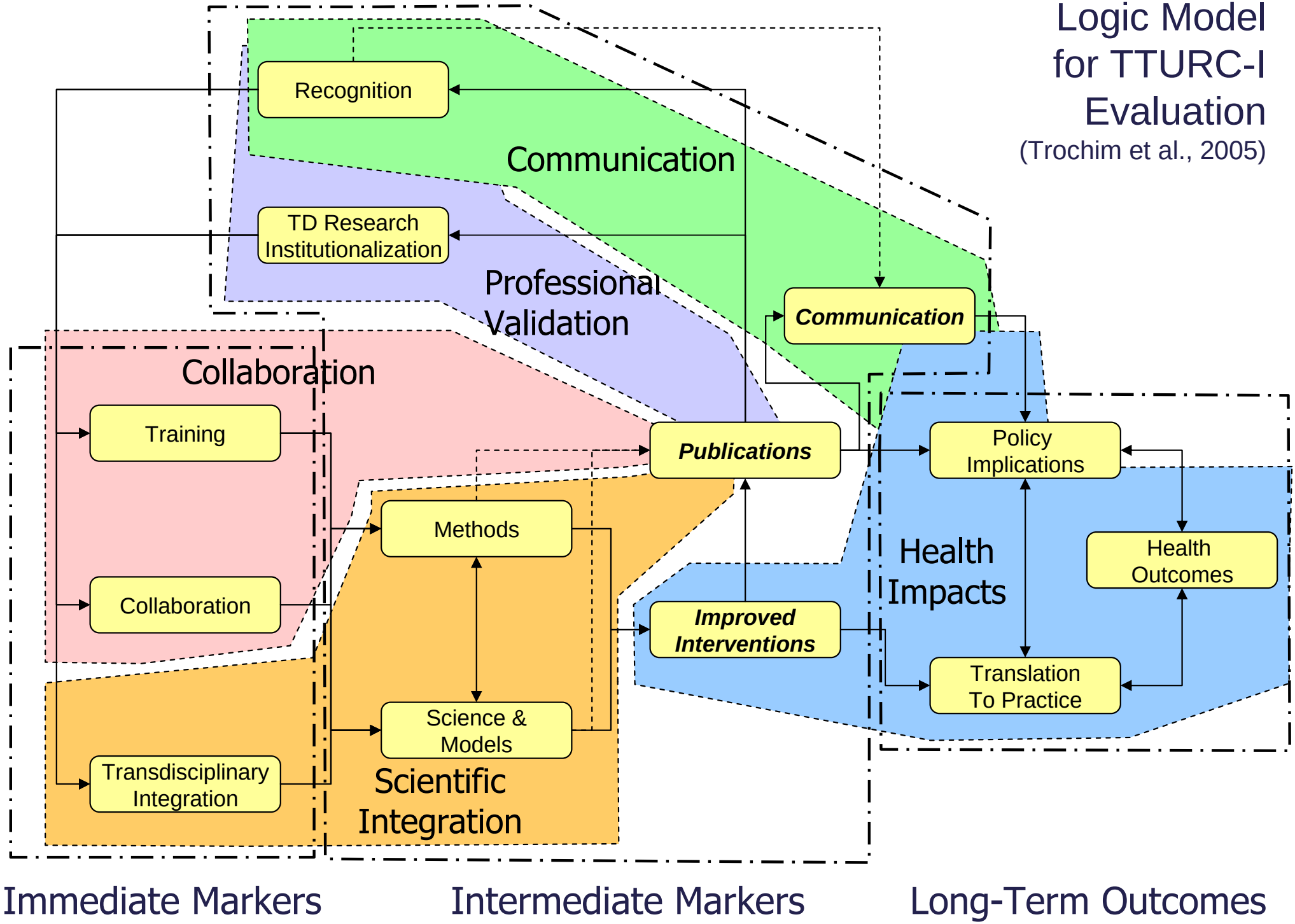
- *Solicited through problem-focused RFAs*
- *Average annual expenditure of $5M per grant*
- *Usual duration of five years with opportunity for competitive renewals*
- *Often incorporate administrative, training, and translational cores in addition to research projects*
- *Typically comprised of multiple geographically-dispersed centers and research sites*

(Trochim, Marcus, Masse, Moser, Weld, 2008)

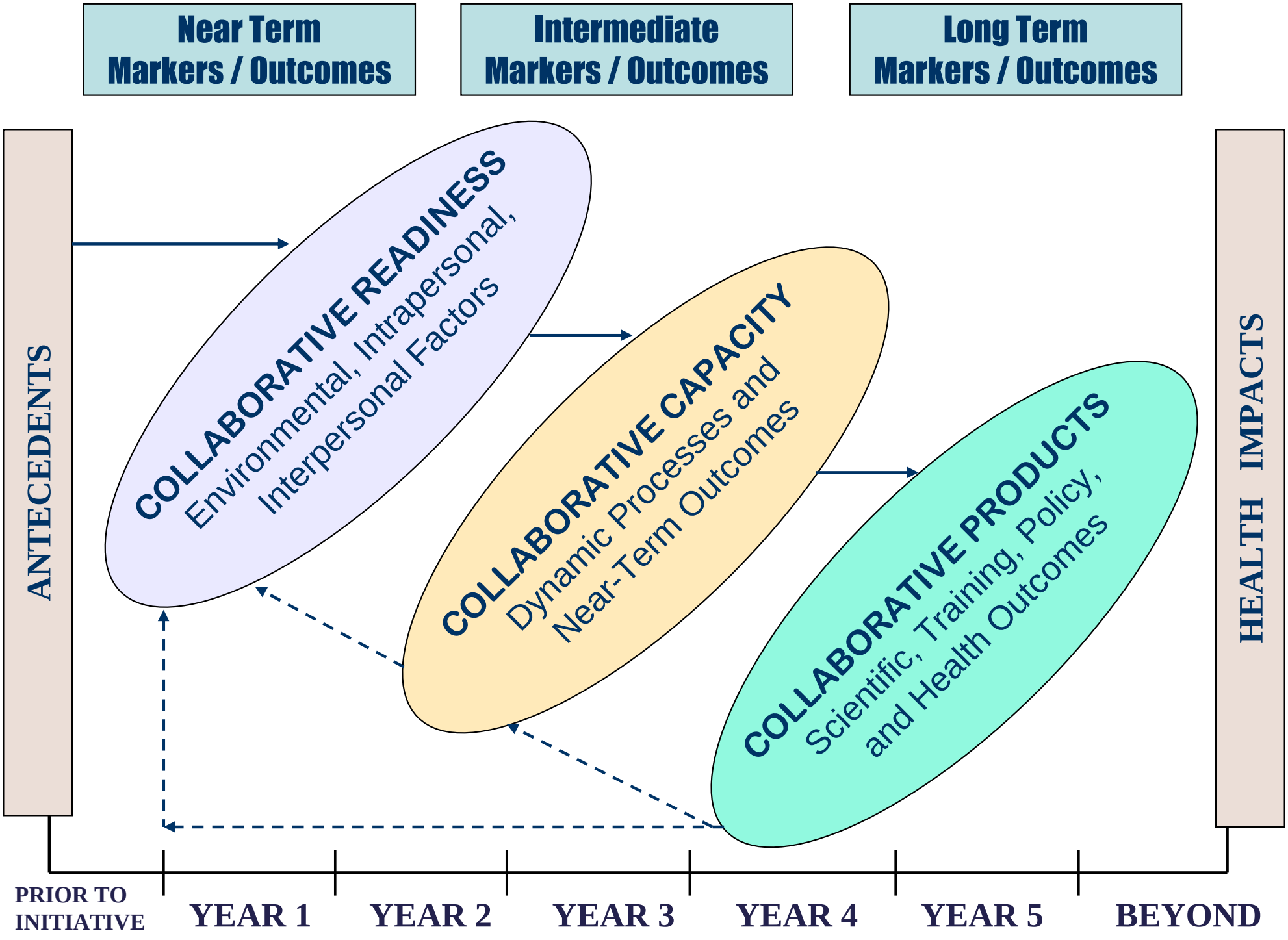
Rudimentary Model of Transdisciplinary Scientific Collaboration



(Fuqua et al., 2004; Stokols et al., 2003, 2005)


Logic Model for TTURC-I Evaluation
(Trochim et al., 2005)
Recognition
Communication
TD Research Institutionalization
Professional Validation
Collaboration
Training
Collaboration
Transdisciplinary Integration
Methods
Science & Models
Scientific Integration
Communication
Publications
Improved Interventions
Policy Implications
Health Outcomes
Translation To Practice
Health Impacts
Immediate Markers
Intermediate Markers
Long-Term Outcomes

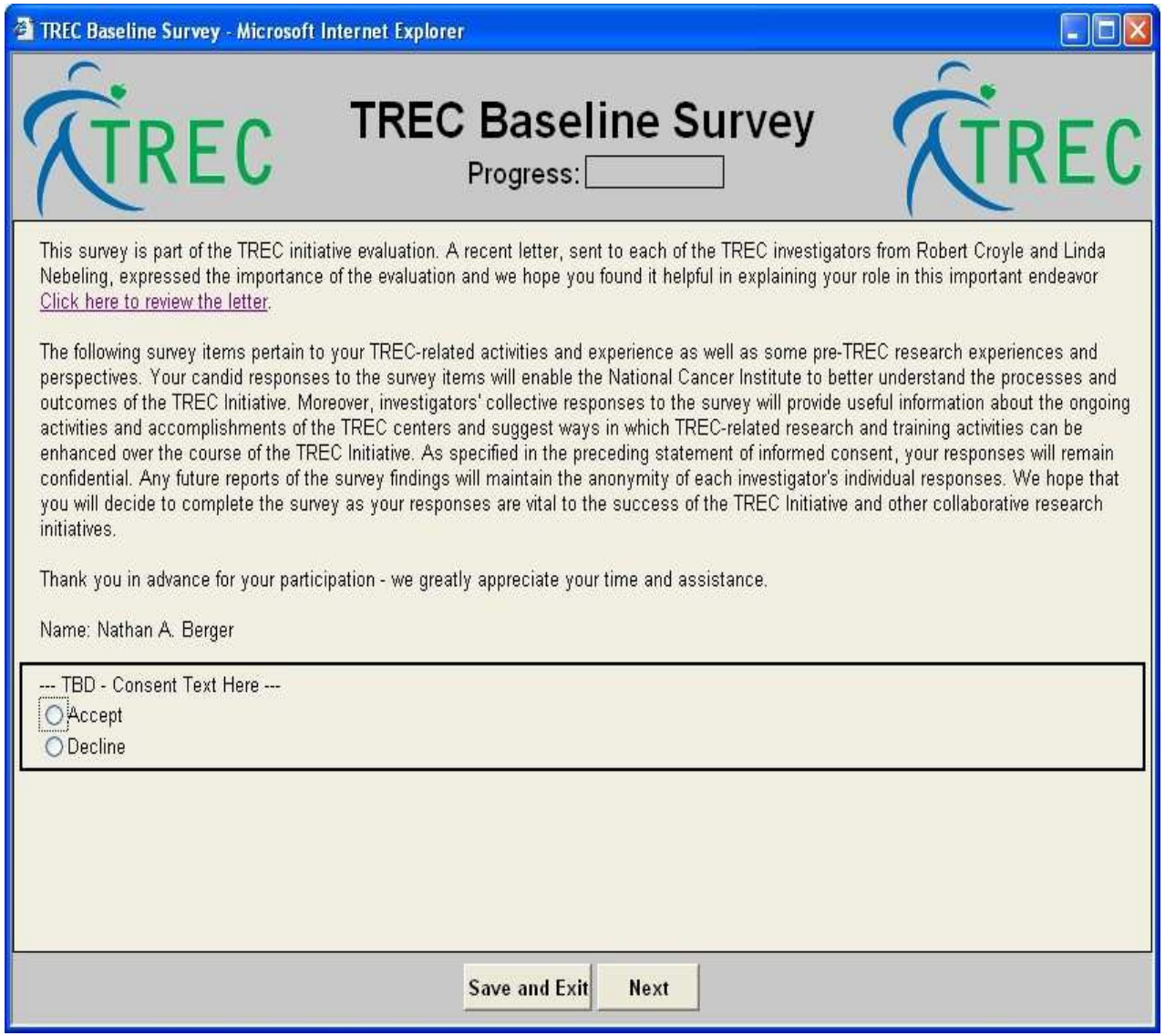
Conceptual Model for Evaluating Collaborative Initiatives *(Hall et al., 2008)*



Antecedent, Process, and Product Measures Used to Evaluate NCI Transdisciplinary Research Centers

- *Researcher Surveys and Interviews*
- *Bibliometric Analyses*
- *Social Network Analyses*
- *Written Product Analyses*

The TREC Baseline Survey March-June 2006



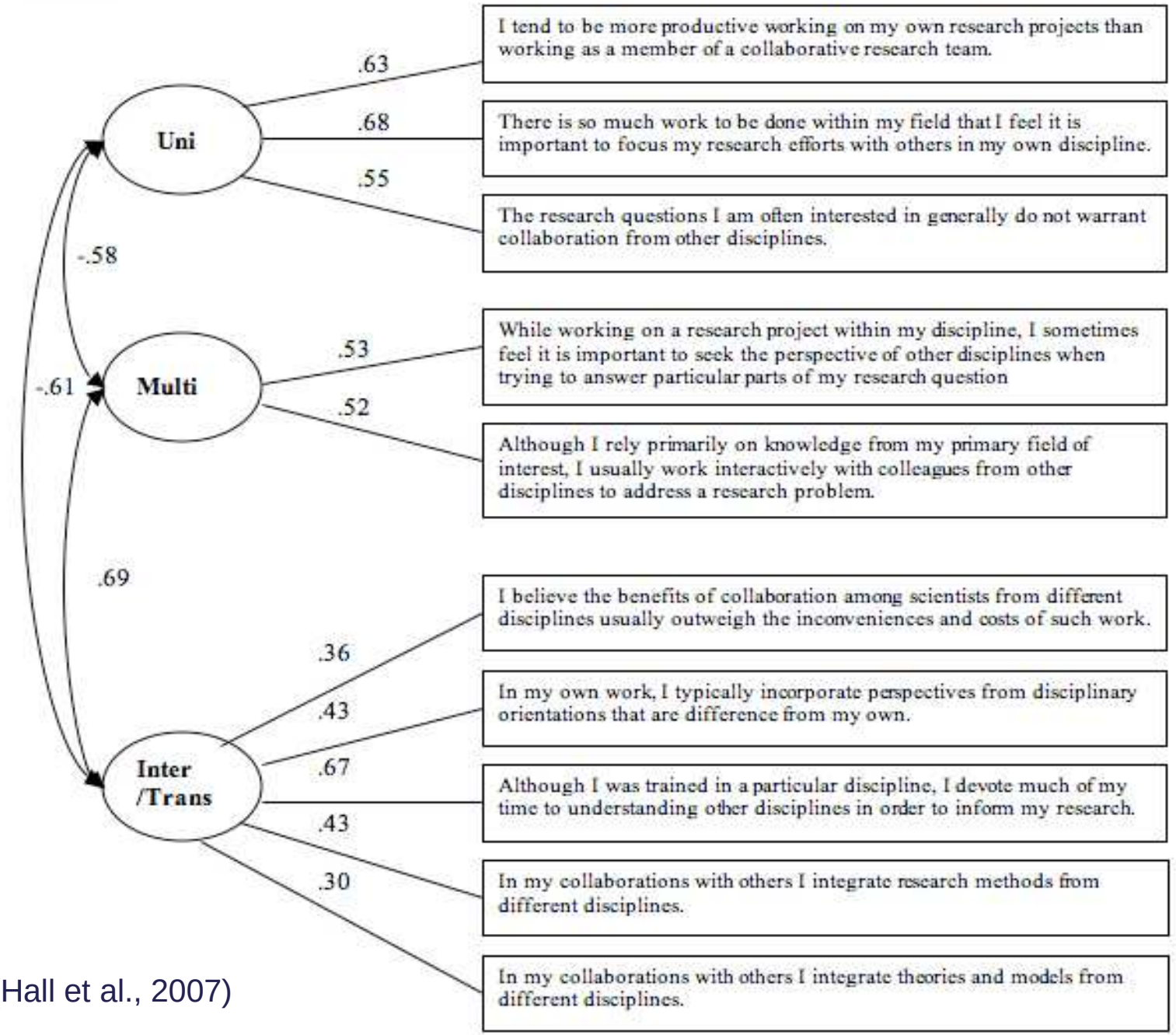
- *New survey measures derived from theoretical and empirical analyses of "collaboration readiness" measures*
- *Development of an Online System for Survey Administration*
- *Coordination of IRB Approvals at Multiple Sites*

Sample Research Orientation Items from the TREC Year-1 Evaluation Survey

Type of Research	Sample Scale Items
UNI	*There is so much work to be done within my field that I feel it is important to focus my research efforts with others in my own discipline.*
MULTI	*While working on a research project within my discipline, I sometimes feel it is important to seek the perspective of other disciplines when trying to answer particular parts of my research question.*
INTER/ TRANS	*In my own work, I typically incorporate perspectives from disciplinary orientations that are different from my own.*
TRANS	*In my collaborations with others I integrate theories and models from different disciplines.*

Items rated on a 5-Point Likert Scale: Strongly Disagree to Strongly Agree

Path Diagram for the Research Orientation Scale Including Factor Loadings and Factor Correlations



(Hall et al., 2007)

Please assess the frequency with which you typically engage in each of the activities listed below using the following 7-point scale.

		Never	Rarely	Once a Year	Twice a Year	Quarterly	Monthly	Weekly
a.	Read journals or publications outside of your primary field	☐	☐	☐	☐	☐	☐	☐
b.	Attend meetings or conferences outside of your primary field	☐	☐	☐	☐	☐	☐	☐
c.	Participate in working groups or committees with the intent to integrate ideas with other participants	☐	☐	☐	☐	☐	☐	☐
d.	Obtain new insights into your own work through discussion with colleagues who come from different fields or disciplinary orientations	☐	☐	☐	☐	☐	☐	☐
e.	Modify your own work or research agenda as a result of discussions with colleagues who come from different fields or disciplinary orientations	☐	☐	☐	☐	☐	☐	☐
f.	Establish links with colleagues from different fields or disciplinary orientations that have led to or may lead to future collaborative work	☐	☐	☐	☐	☐	☐	☐
g.	Collaborate with members of your own TREC centers on developmental projects.	☐	☐	☐	☐	☐	☐	☐
h.	Collaborate with members of other TREC centers on developmental projects	☐	☐	☐	☐	☐	☐	☐
i.	Collaborate with investigators from other TREC centers in ways other than developmental projects	☐	☐	☐	☐	☐	☐	☐

NCI Collaborative Activities Scale

Relationships Between Research Orientation and Collaborative Behavior Scores

Those who rank higher on the Uni-disciplinary factor:

- Engage in fewer cross-disciplinary collaborative activities (r =-.35)
- Have fewer collaborators (r = -.36)

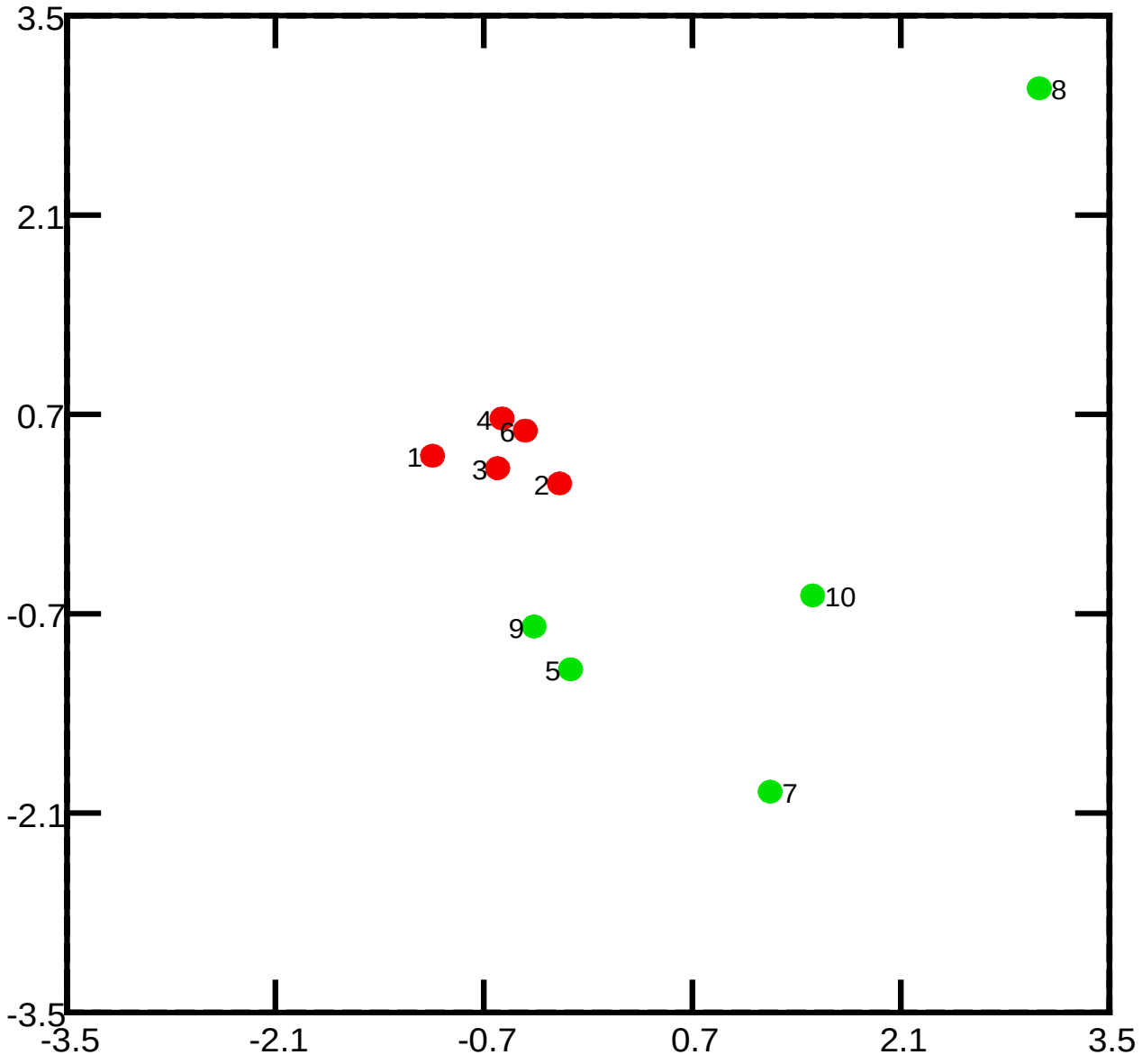
Those who rank higher on the Multi-disciplinary factor:

- Engage in more cross-disciplinary activities (r = .52)
- Have more collaborators (r = .36)

Those who rank higher on the Inter/Trans-disciplinary factor:

- Engage in more cross-disciplinary activities (r = .45)

Correspondence Analysis of the Degree to Which TTURC-I Investigators Worked Closely With Each Other to Integrate Ideas



(Stokols et al, 2005)

Assessing the Value of Team Science

A Study Comparing Center- and Investigator-Initiated Grants

Kara L. Hall, PhD, Daniel Stokols, PhD, Brooke A. Stipelman, PhD, Amanda L. Vogel, PhD, MHS, Annie Feng, PhD, Beth Masimore, PhD, Glen Morgan, PhD, Richard P. Moser, PhD, Stephen E. Marcus, PhD, David Berrigan, PhD

This activity is available for CME credit. See page A3 for information.

Background: Large cross-disciplinary scientific teams are becoming increasingly prominent in the conduct of research.

Purpose: This paper reports on a quasi-experimental longitudinal study conducted to compare bibliometric indicators of scientific collaboration, productivity, and impact of center-based transdisciplinary team science initiatives and traditional investigator-initiated grants in the same field.

Methods: All grants began between 1994 and 2004 and up to 10 years of publication data were collected for each grant. Publication information was compiled and analyzed during the spring and summer of 2010.

Results: Following an initial lag period, the transdisciplinary research center grants had higher overall publication rates than the investigator-initiated R01 (NIH Research Project Grant Program) grants. There were relatively uniform publication rates across the research center grants compared to dramatically dispersed publication rates among the R01 grants. On average, publications produced by the research center grants had greater numbers of coauthors but similar journal impact factors compared with publications produced by the R01 grants.

Conclusions: The lag in productivity among the transdisciplinary center grants was offset by their overall higher publication rates and average number of coauthors per publication, relative to investigator-initiated grants, over the 10-year comparison period. The findings suggest that transdisciplinary center grants create benefits for both scientific productivity and collaboration.

(Am J Prev Med 2012;42(2):157–163) Published by Elsevier Inc. on behalf of American Journal of Preventive Medicine

Background

The rapid proliferation of scholarly knowledge and the increasing complexity of social and scientific problems have prompted growing investments in team science initiatives.[1–8] These initiatives typically last 5 to 10 years and are dispersed across different departments, institutions, and geographic locations.[5,9–11] Many of these initiatives are based on the belief that team-based research integrating the strengths of multiple disciplines may accelerate progress toward resolving complex societal and scientific problems.[12,13] The health sciences, in particular, have embraced this approach to address pervasive public health threats such as those associated with smoking, obesity, and environmental carcinogens.[14–16]

Cross-disciplinary collaboration ranges from the least-integrative form of team science, *multidisciplinary collaboration*, to the most-integrative, *transdisciplinary collaboration*, with *interdisciplinary collaboration* falling between those.[17,18] Participants in multidisciplinary and interdisciplinary collaborations remain conceptually and methodologically anchored in their respective disciplines, although some exchange of diverse perspectives occurs among research partners. Participants in transdisciplinary collaborations transcend their disciplines, en-

From the Division of Cancer Control and Population Sciences (Hall, Stipelman, Morgan, Moser, Berrigan), National Cancer Institute; the Center for Bioinformatics and Computational Biology (Marcus), National Institute of General Medical Sciences, NIH, Bethesda, Clinical Research Directorate/CMRP (Vogel), SAIC-Frederick, Inc., NCI-Frederick, Frederick, Maryland; Discovery Logic (Masimore), Rockville, Maryland; the School of Social Ecology (Stokols), University of California, Irvine, Irvine, California; and Feng Consulting (Feng), Livingston, New Jersey

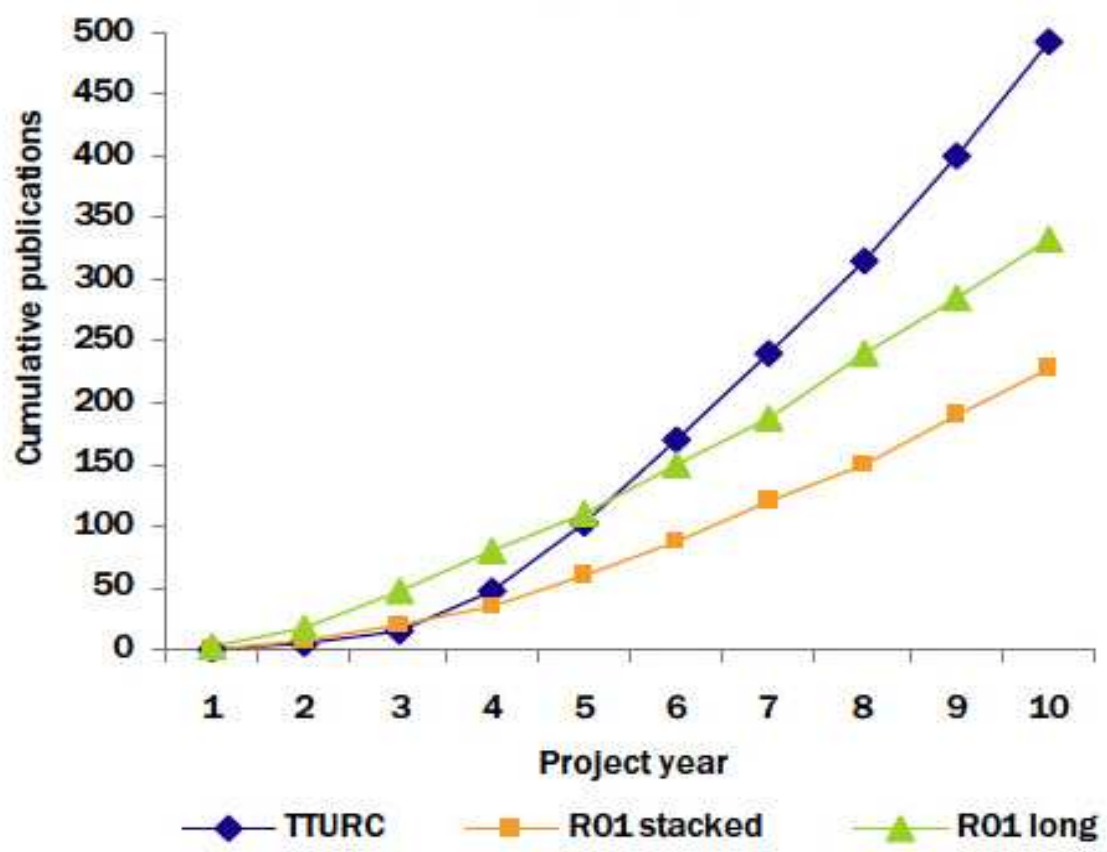
Stephen Marcus was employed at the National Cancer Institute when this research was completed.

Address correspondence to: Kara L. Hall, PhD, the Division of Cancer Control and Population Sciences, National Cancer Institute, 6130 Executive Blvd., MSC 7338, Executive Plaza North, Room 4078, Bethesda MD 20892. E-mail: hallka@mail.nih.gov.

0749-3797/$36.00

doi: 10.1016/j.amepre.2011.10.011

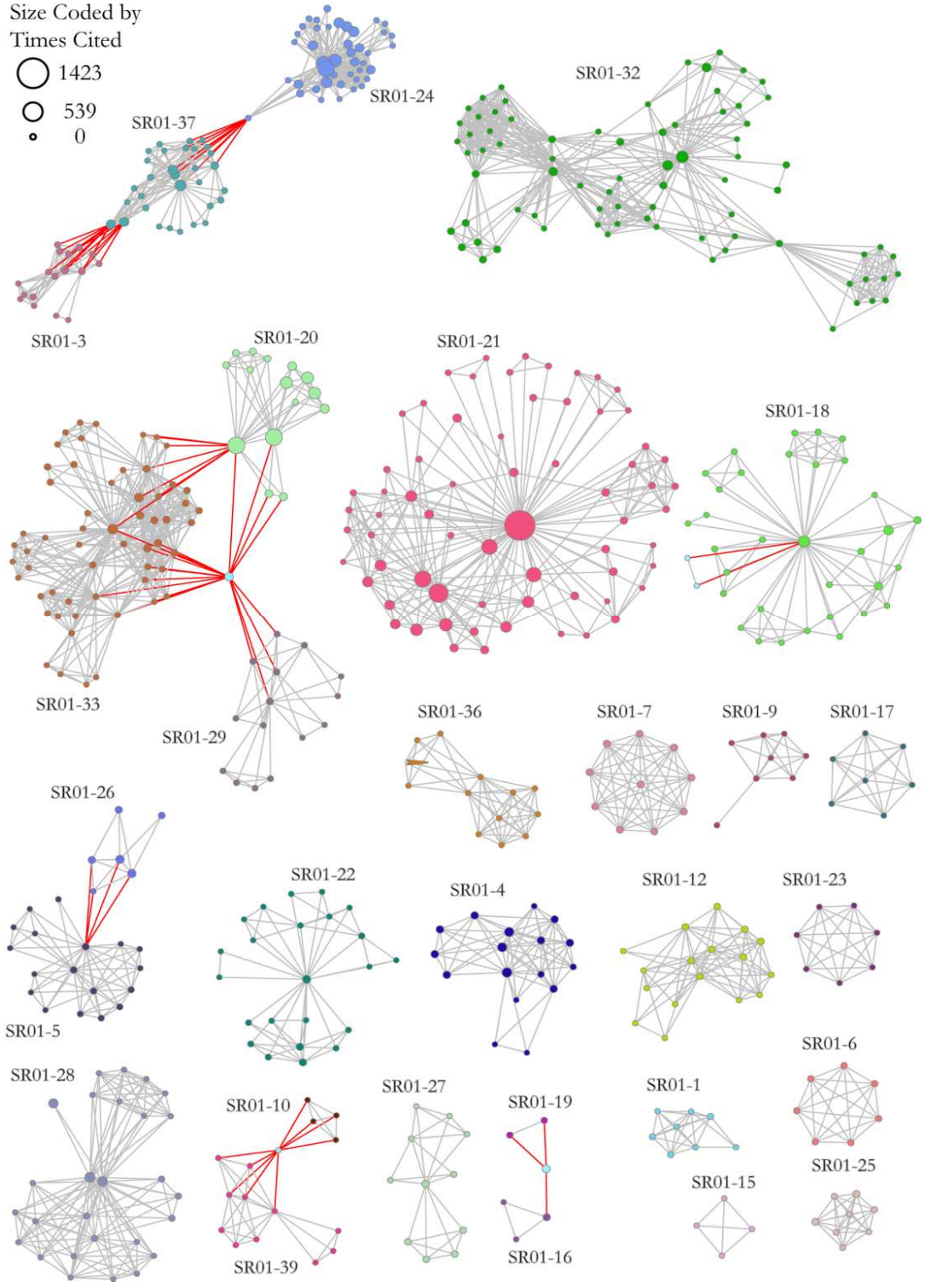
Publications Generated by TD Center Grants and R01 Investigator-Initiated Grants

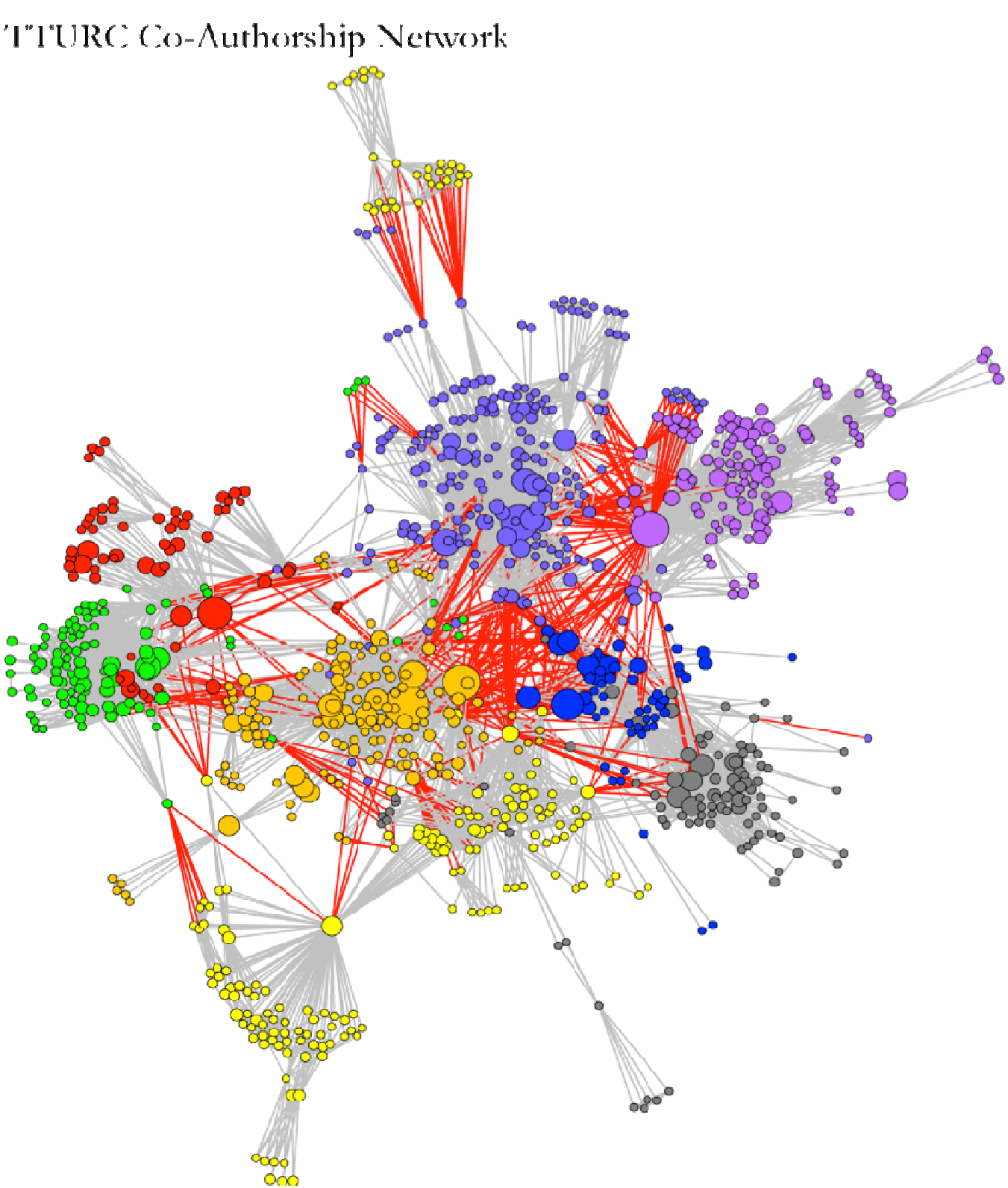


TD center publications have longer start up period compared to R01grants but become more productive over time.

(Hall, Stokols, Stipelman, Vogel, et. al., 2012)

Stacked R01 Co-Authorship Network (from Hall et al., 2011)





from Hall et al., 2012)

Written Products Protocol

Sample Items

VI. Indicate your subjective rating of the proposal regarding its **type** of cross-disciplinary integration (select one):

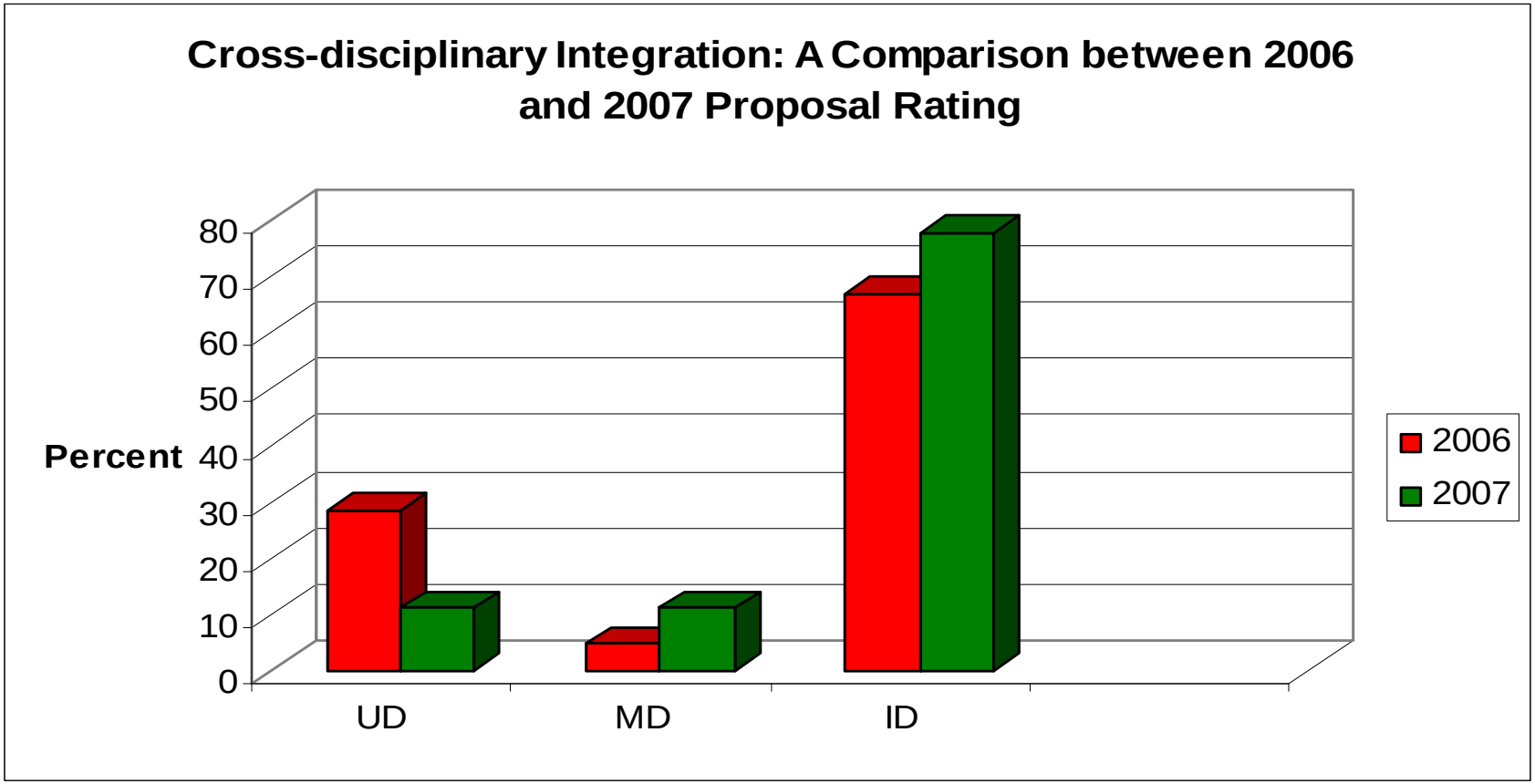
	Type	Definition of cross-disciplinary integration type	Example of cross-disciplinary integration type
☐	(1) Unidisciplinary	***Unidisciplinarity*** is a process in which researchers from a *single discipline* work together to address a common research problem.	A team of pharmacologists collaborate on a laboratory study of the relationships between nicotine consumption and insulin metabolism.
☐	(2) Multidisciplinary	***Multidisciplinarity*** is a *sequential* process whereby researchers in different disciplines work *independently*, each from his or her own discipline-specific perspective, with a goal of eventually combining efforts to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist each contribute sections to a multi-authored manuscript that reviews research in their respective fields pertaining to the links between nicotine consumption, changes in brain chemistry and caloric intake induced by nicotine, and physical activity levels.
☐	(3) Interdisciplinary	***Interdisciplinarity*** is an *interactive* process in which researchers work *jointly*, each drawing from his or her own discipline-specific perspective, to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist conduct a collaborative study to examine the interrelations between patterns of nicotine consumption, brain chemistry, caloric intake, and physical activity levels. Their research design incorporates conceptual and methodological approaches drawn from each of their respective fields.
☐	(4) Transdisciplinary	***Transdisciplinarity*** is an *integrative* process by which researchers work jointly to develop and use a shared conceptual framework that *synthesizes and extends* discipline-specific theories, concepts, and/or methods to create *new* models and language to address a common research problem.	A pharmacologist, health psychologist, and neuroscientist conduct a collaborative study to examine the interrelations between nicotine consumption, brain chemistry, caloric intake, and physical activity levels. Based on their discussions, they develop a neurobehavioral model of the links between tobacco consumption, brain chemistry, insulin metabolism, physical activity, and obesity that integrates and extends the concepts and methods drawn from their respective fields.

VII. Indicate your overall subjective rating of the proposal regarding the **scope of transdisciplinary integration**. In other words, indicate the breadth or extent to which there is integration of analytic levels, analytic methods, and discipline-specific concepts (circle one number):

1 2 3 4 5 6 7 8 9 10

None Moderate Substantial

Changes in Cross-Disciplinary Integration from 2006 to 2007 TREC Pilot Proposal Ratings



The percentage of proposals incorporating either multi- or inter-disciplinary approaches increased from 2006 to 2007.

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NAKFI Written Products Protocol

Adapted from the NCI WPP

Type of Cross-Disciplinary Integration	Number of Grants	Project Characteristics
Transdisciplinary	1	Creative integration of disparate disciplines (tools, concepts, or methods) leading to a new idea
Interdisciplinary	3	Application of tools and theories of one discipline to another Consolidation / synthesis of different research areas
Multidisciplinary	5	Investigators working separately on different areas of the problem without much integration
Unidisciplinary	2	

Sample ratings of seed grant reports in terms of their unidisciplinary or cross-disciplinary emphases

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NAKFI Seed Grant Report Measures

Quantitative Ratings		
Reviewers:		
Facets of Integration		
Concepts	3	3
Implementation	1	2
Analytic levels	2	3
Analytic methods	2	3
Discipline-specific concepts	3	4
Broad Measures		
Intellectual quality	3	4
Creativity	4	4
Scientific impact	4	4
Societal impact	3	4
Overall quality	4	4
Inter-rater Reliability:		

Scientific Contributions Identified	
Development of a new theory	☑
Extension of an existing theory	
Development of a new methodology	☑
Development of a new translational tool	
Development of a new device	☑
Other Contribution	☑

Collaborative Resources Identified	
Development of a new research center	
Grant support from other sources	☑
Additional institutional support	
Graduate student and/or post-doctoral scholar research support	☑
New research collaborations	
Organization of interdisciplinary meetings	☑
Development of electronic resources	
Establishment of new interdisciplinary training programs	☑

Each seed grant report was evaluated by at least two independent peer reviewers on both quantitative and qualitative dimensions.

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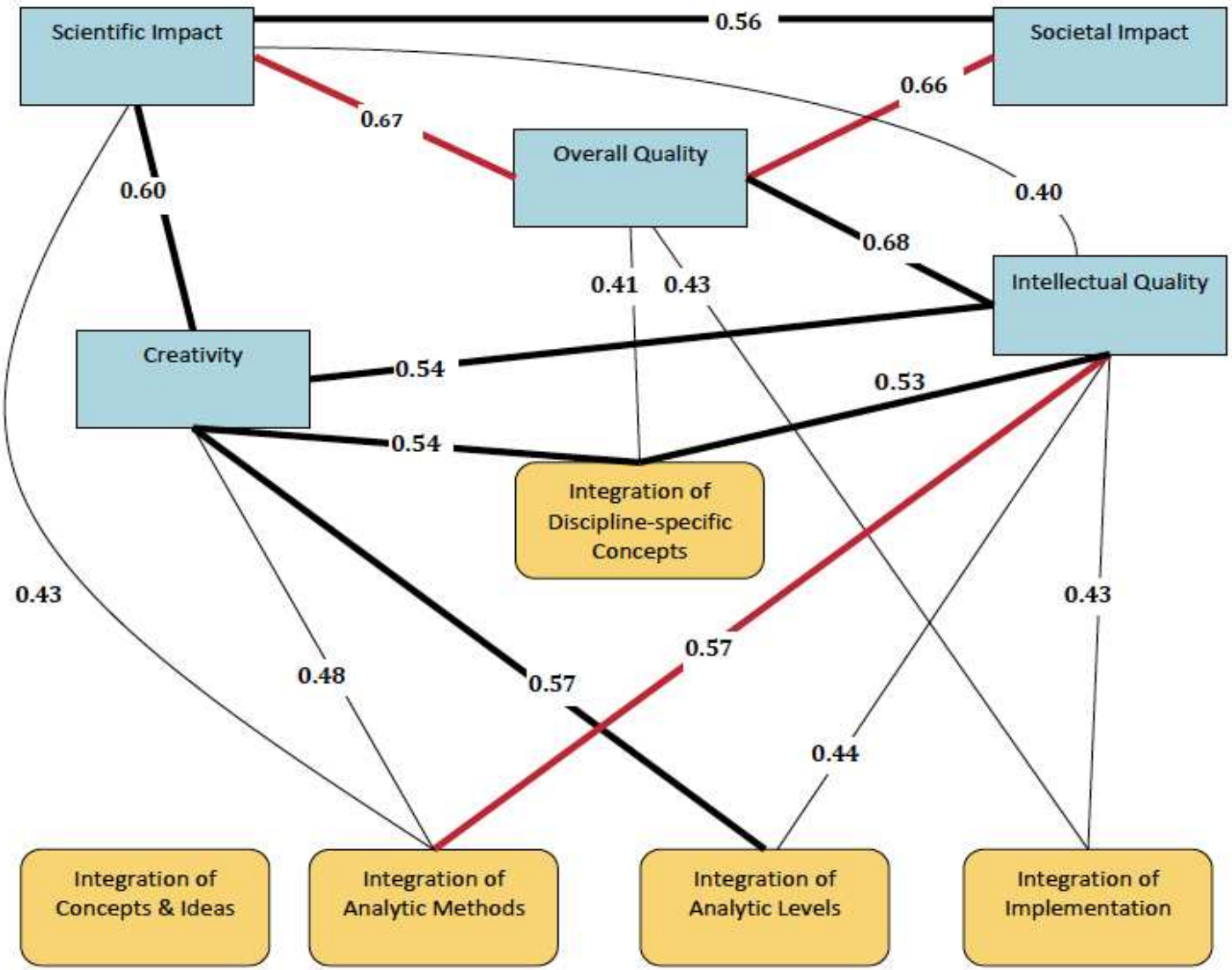
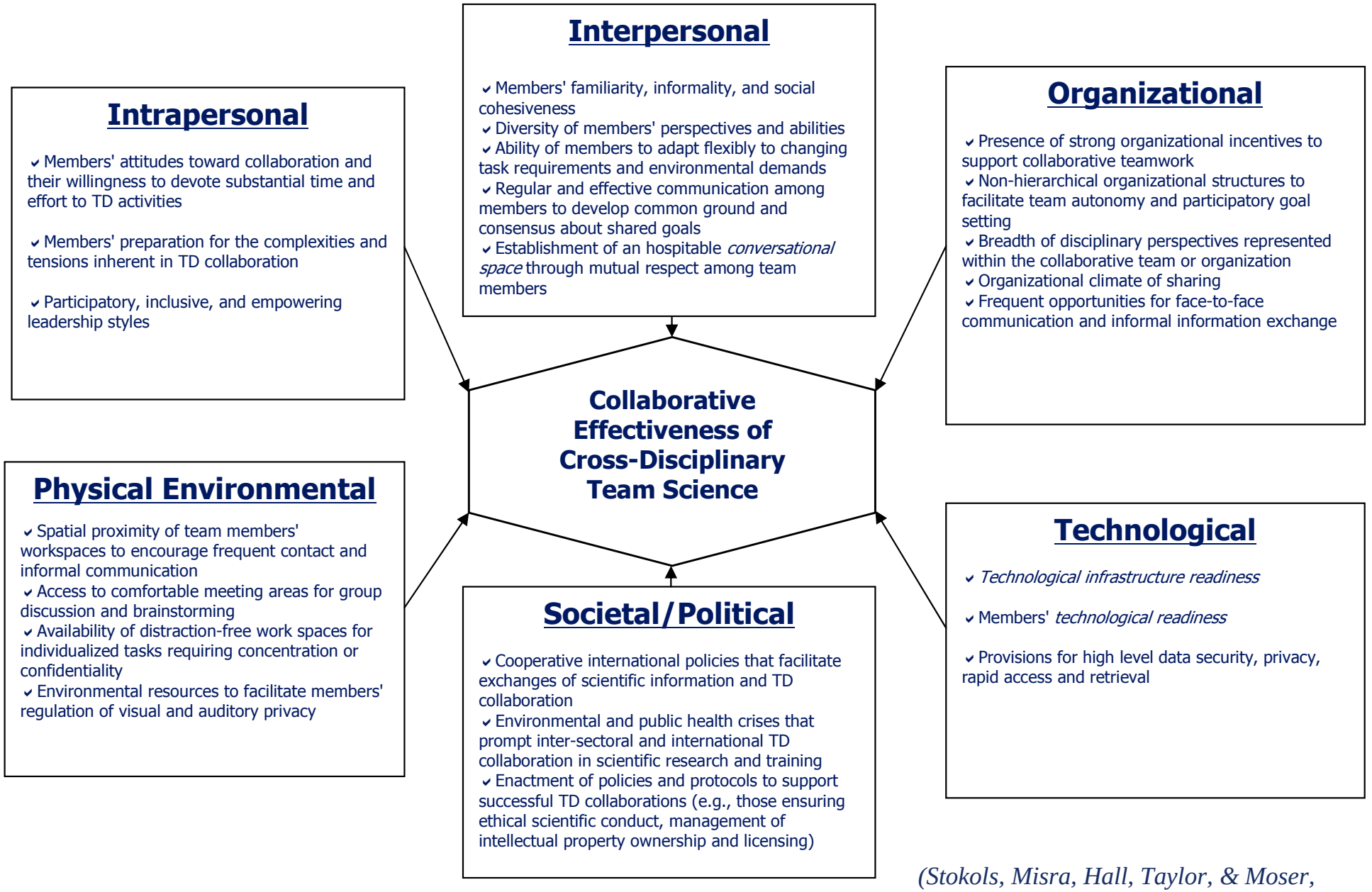
Evaluation of NAKFI Seed Grants Using the Written Products Protocol

Figure 1: Schematic Representation of Correlations between WPP Items Genomics & Smart Prosthetics Data Combined (N=25)



Practical Implications and Future Directions

Multiple Influences on the Effectiveness of Team Science

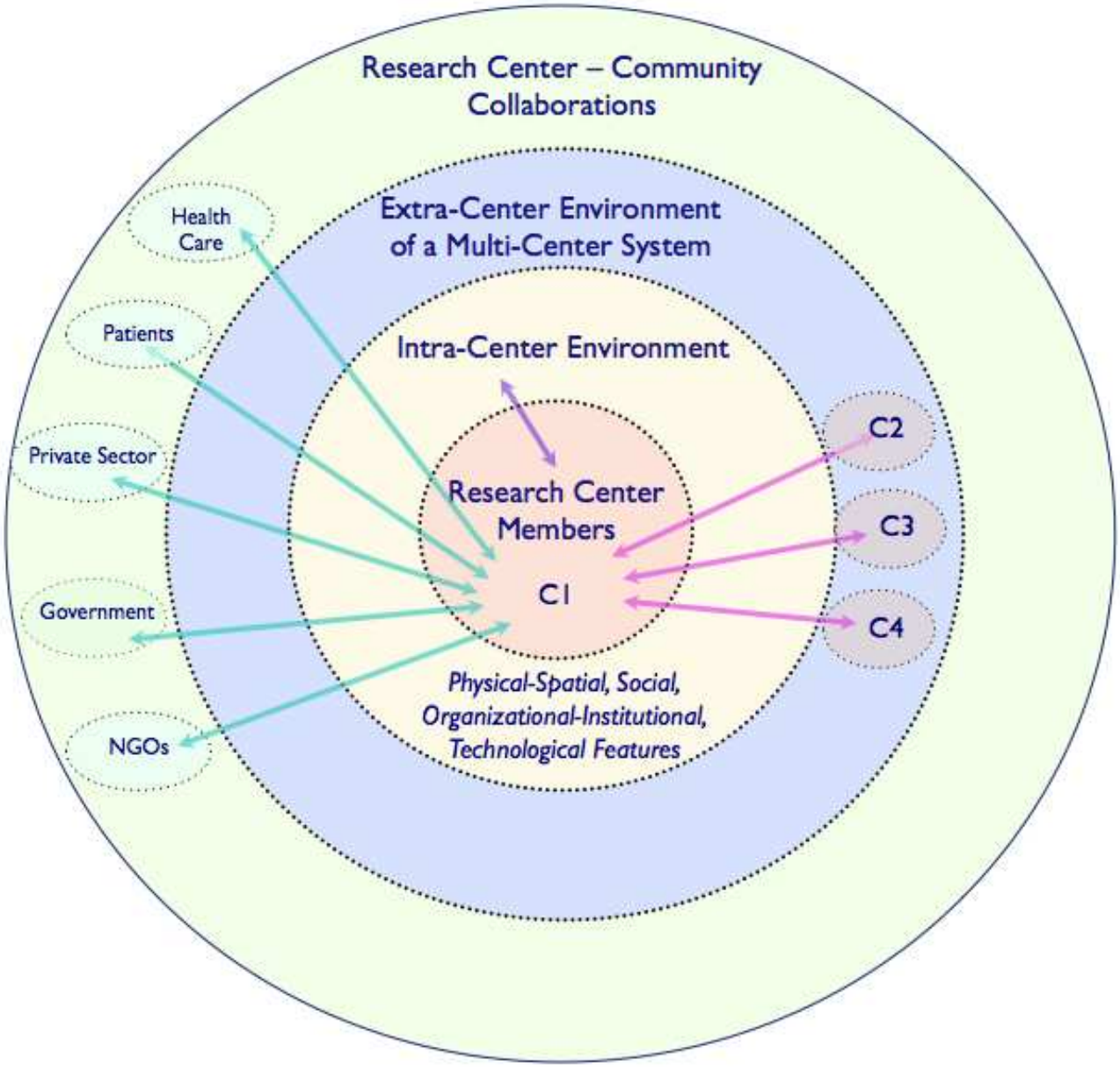


(Stokols, Misra, Hall, Taylor, & Moser, 2008)

High-Leverage Collaboration Readiness Factors

- Leaders with collaborative and inclusive orientations
- Strong institutional support for cross-disciplinary collaboration
- Environments and technologies that enable collaboration
- Participants share a strong commitment to CD collaboration
- Team members have worked together on prior projects
- Ample training and experience in cross-disciplinary team science

The Ecology of Translational Team Science Centers



(Stokols, 2012)

Externalizing Shared Values and Team Identity Through the Physical Environment

Pacificare, Cypress, CA

LSA Associates, Irvine, CA

Google-Zurich

LSA Associates, Irvine, CA

Educational Challenge Posed by the Requirements of Team Science

Nurturing a Transdisciplinary Orientation

A set of personal attributes that emerges gradually over the course of a scholar's career and is shaped through exposure to multiple learning environments, mentors, and research settings

Undergraduate Interdisciplinary Research Teams

Key Facets of a TD Orientation

- **TD Values**- *that predispose students, scholars, and practitioners toward acquiring a broad understanding of research and societal problems; the motivational core of a TD orientation*

- **Beliefs** – *that integrating concepts and methods from diverse fields is essential for achieving important scientific and societal advances*

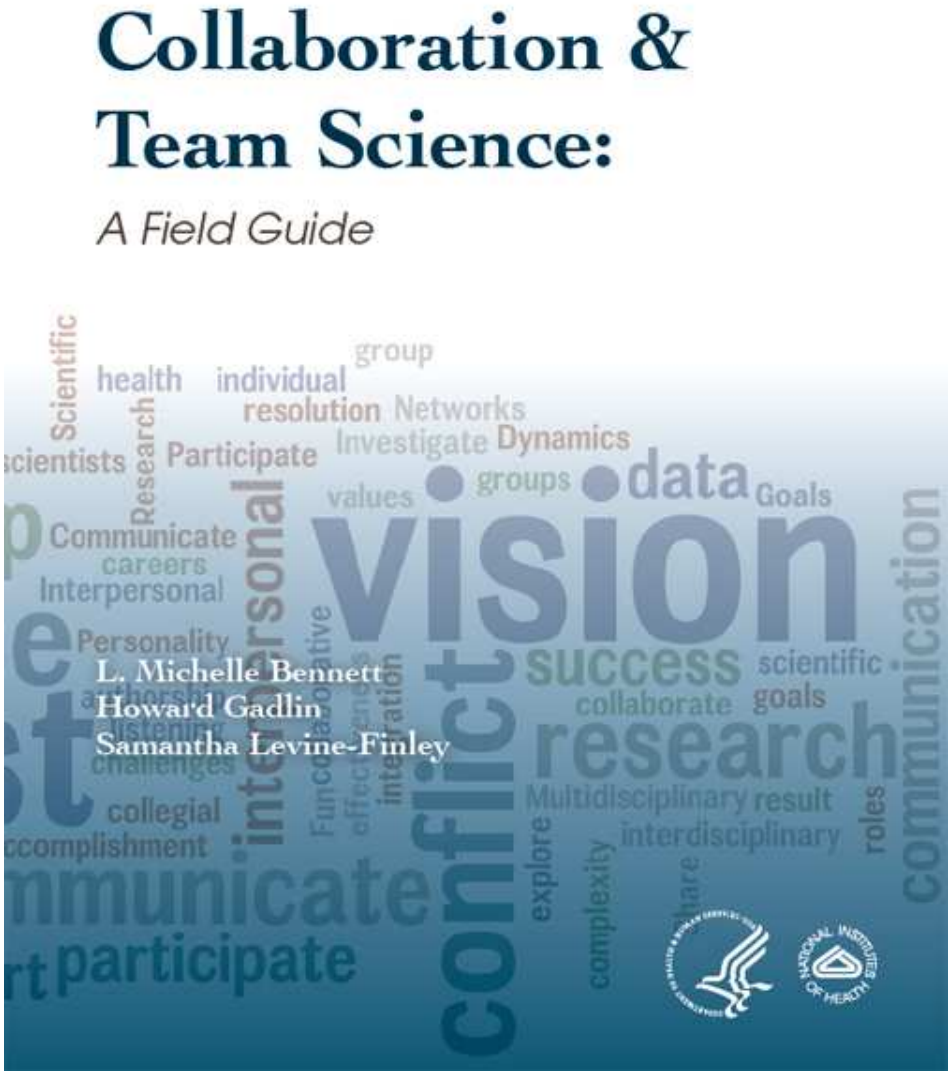
- **Attitudes** – *favorable toward engaging in integrative scholarship bridging multiple disciplines*

- **Behaviors** – *conducive to learning about and synthesizing concepts and methods from disparate fields, and collaborating effectively as a research team member*

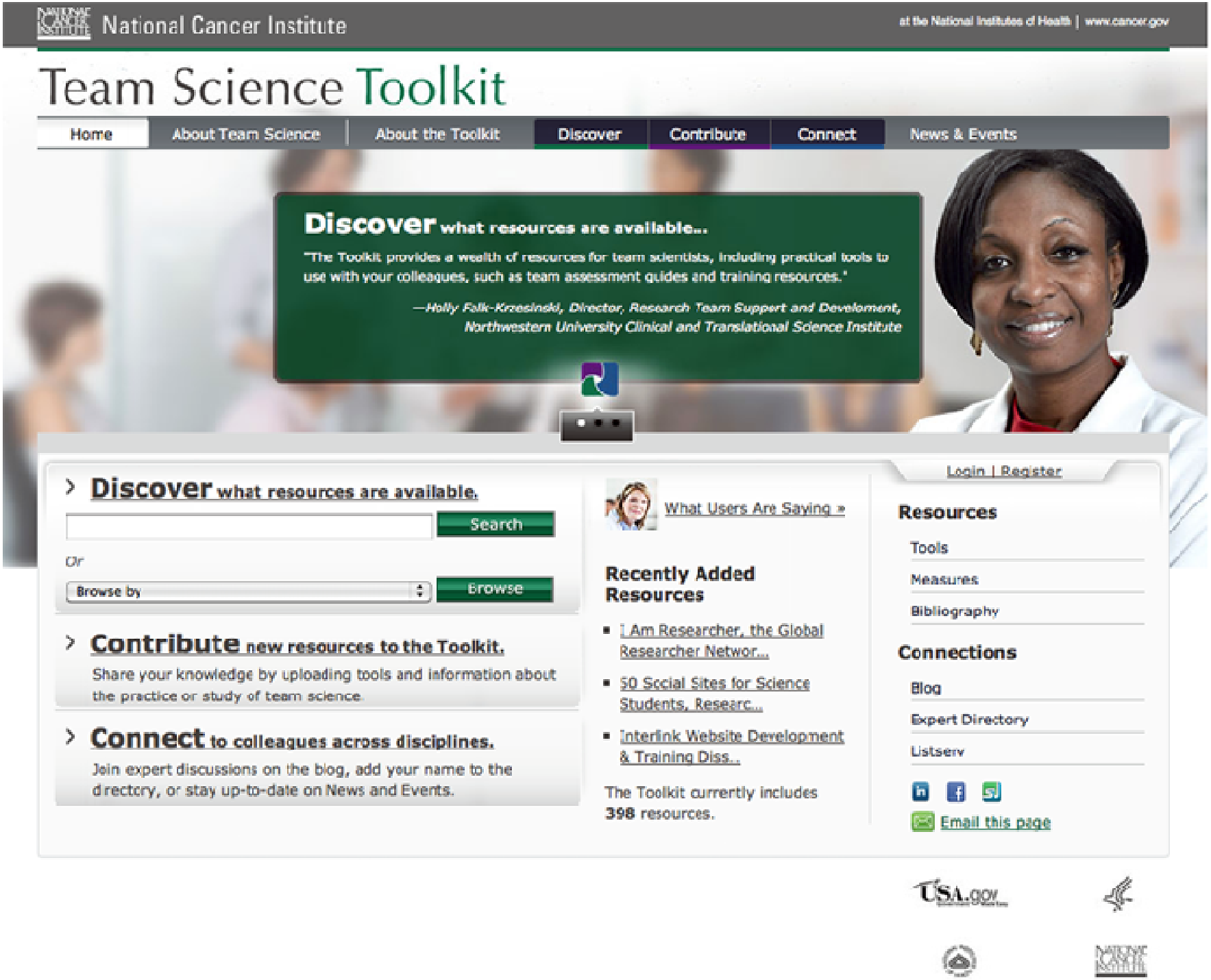
- **Conceptual skills and knowledge** – *that enable scholars to traverse multiple levels of analysis and to consider the interrelations among them; synthesize disparate disciplinary approaches; and develop novel conceptualizations that transcend pre-existing constructs and theories*

Methods and Tools to Enhance the Practice of Team Science

NIH Ombuds Office – Team Science Field Guide



https://ccrod.cancer.gov/confluence/display/NIHOMBUD/Home



https://www.teamsciencetoolkit.cancer.gov/public/home.aspx?js=1

SciTS Online Training Modules

NUCATS
CLINICAL AND TRANSLATIONAL SCIENCES INSTITUTE

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http://scienceofteamscience.northwestern.edu/team-science-resources

http://www.teamscience.net

Thank you!