Team-Based Science: Strategies for Success, Practical Tools, and Future Directions

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NCI CBIIT

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Overview

Goal: Enhance understanding of evidence and resources for conducting, managing, and supporting effective and efficient team science

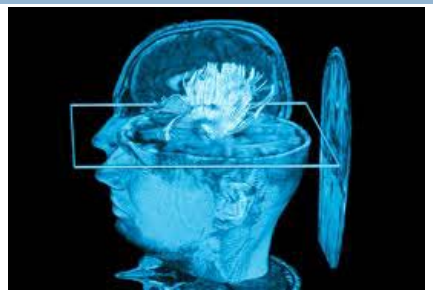
Objective: Provide an overview of conceptual issues, key empirical findings, and theoretical and practical tools for enhancing team science

Introduction

Team Science and the Science of Team Science

WHAT ARE WE TRYING TO DO?

NIH Mission



….enhance health, lengthen life, and reduce illness and disability

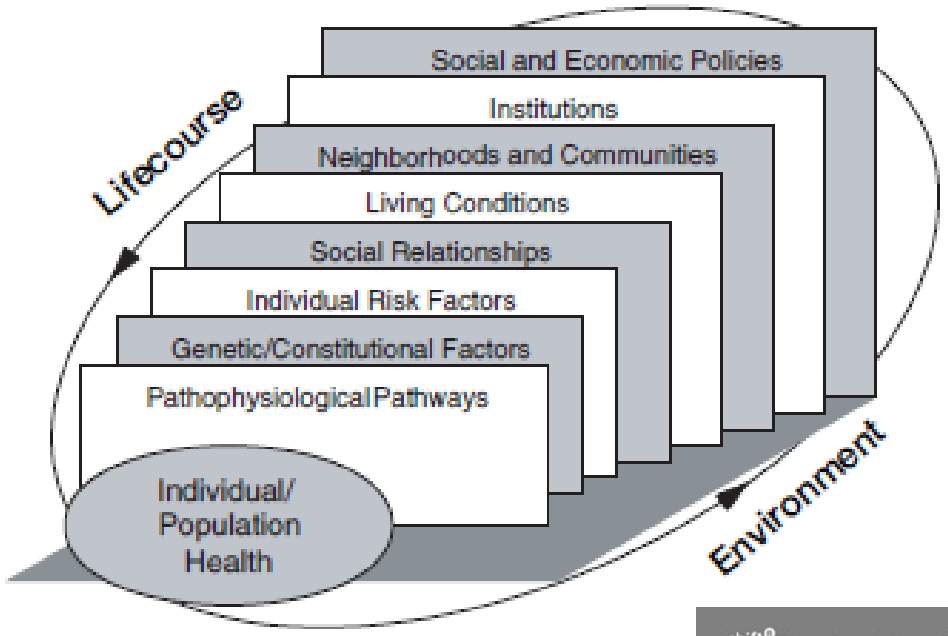
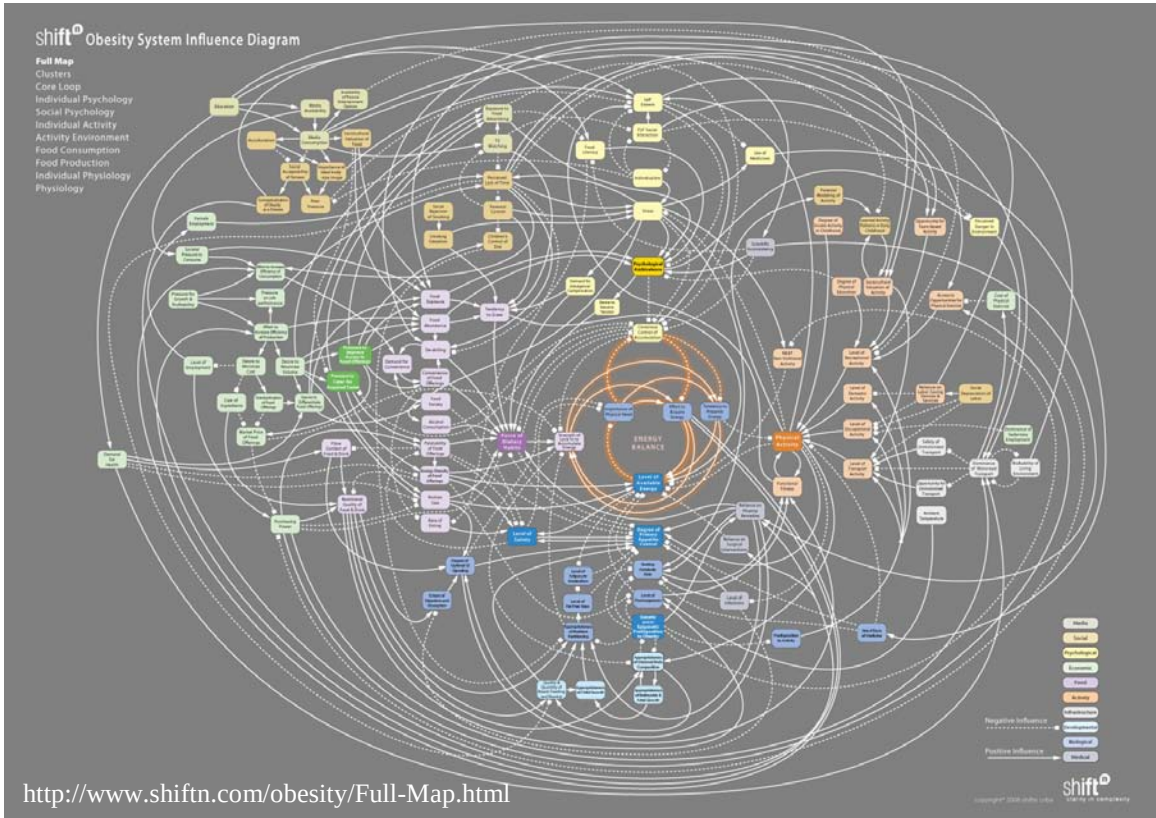


FIGURE A–2 Multilevel approach to epidemiology.
SOURCE: Institute of Medicine (2000).

The societal and scientific problems are complex –

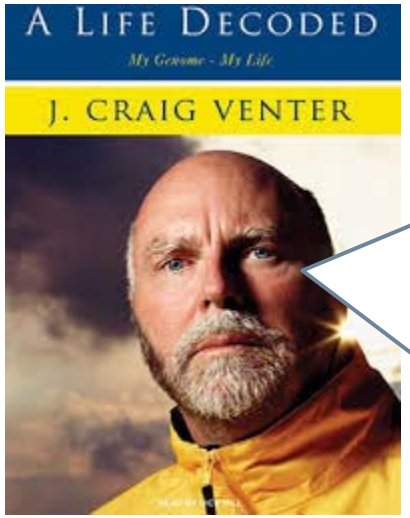
Multi-level, multi-factorial, interacting influences.



How can it be done?

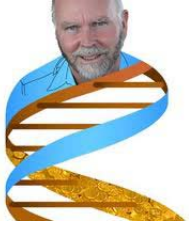
Expert opinion

What are you **most proud of** now? What would you want, if you walk out of here and don't make it across the street – here is **what Craig Venter did for us**?



"Aside from my direct scientific contributions that I have made with my teams, I think I brought a **new approach back into science that makes team-based discovery the way to be far more effective** than the linear approach we've had with government funding and universities. And my **small teams** - having **multi-disciplinary** teams - that got the first genome, the first human genome, synthetic cells - that there has been **constant major breakthroughs by this small team**. And **it is team science – I am the orchestra conductor**, but it is this phenomenal team…that made the first synthetic life happen. And I think **if I have a skill set, it's putting the best teams together and motivating them by asking the right questions."**

Charlie Rose Show, Oct 22, 2013



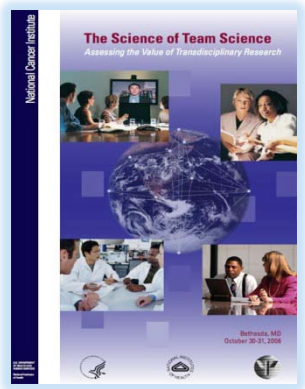
SHOULD WE TAKE VENTER'S WORD FOR IT?
The Science of Team Science

- Venter's response raises questions, such as:
  - Can **team-based research…**
    - **Accelerate innovation**?
    - **Produce more holistic discoveries, faster?**
    - **Generate more comprehensive solutions** to our most complex scientific and societal problems?
  - How can **funding agencies and universities advance science through team-based approaches**? What **policies** are needed?
  - What **characteristics and skills of leaders and team members** facilitate successful team collaboration in science?

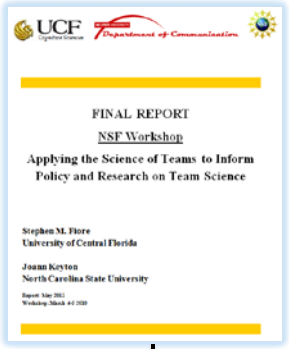
The **Science of Team Science** (SciTS) is a cross-disciplinary field of study that aims to: (1) ***build an evidence-base*** and (2) ***develop translational applications*** to help maximize the efficiency and effectiveness of team-based research.

Building the SciTS Evidence-base

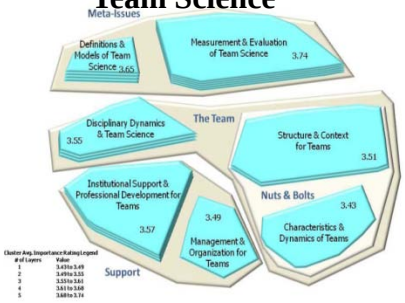
NCI Conference: the Science of Team Science: Assessing the Value of Transdisciplinary Research



Applying the Science of Teams to inform Policy and Research on Team Science



Mapping a Research Agenda for the Science of Team Science



Annual International Science of Team Science Conference

NORTHWESTERN UNIVERSITY

NUCATS
Clinical and Translational Sciences Institute

SciTS 2014
Building the knowledge base for effective team science

2006 2008 2010 2011 2012 2013 2014

Science of Team Science Journal Supplement

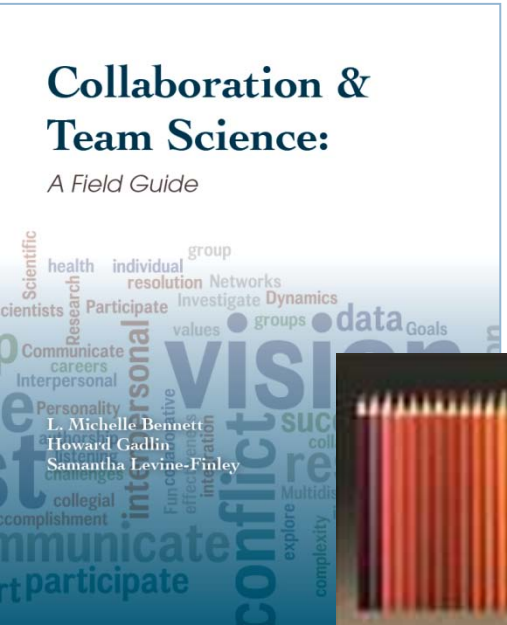
Team Approaches to Science, Practice, and Policy in Health

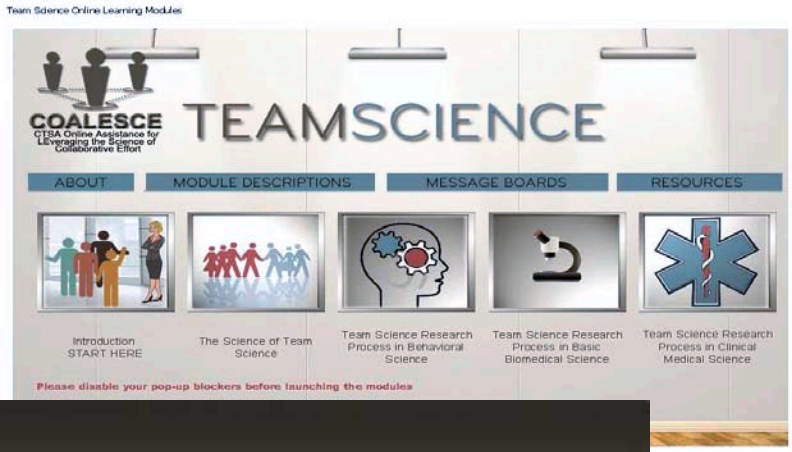
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

NATIONAL ACADEMIES CONSENSUS STUDY OF THE SCIENCE OF TEAM SCIENCE (2012-2014)

Collaboration Science and Translational Medicine

Developing Translational Applications





What is "Team Science"

Team science - *the domain* - the enterprise of science done in a team or multi-team configuration; including:

- **Individuals** - researchers, administrators, funders, publishers, policy makers
- **Contexts** - departments, centers, institutes, universities (etc).

- **Science teams** - *the actors* - two or more researchers who collaborate as a team to conduct research in an interdependent fashion.

What is "Team Science"?

Scientific work conducted interdependently by a **team of two or more researchers**.

Teams and their scientific work vary within and across -

- Team dimensions
  - ***Team Size*** – 2 (small team) to 2000 (team of teams)
  - ***Discipline*** – number and types involved (basic science, social science, etc.)
  - ***Geographic distribution*** -- co-located or dispersed
  - ***Context*** –number and type of research organization (e.g., academia, gov't, industry)
- Scientific approach
  - ***Degree of Integration*** - uni-disciplinary to trans-disciplinary
  - ***Methods*** – number and types of methodological approaches used
  - ***Levels of analysis*** - number and types of "levels" of analysis (from cells to society) included to address the scientific problems

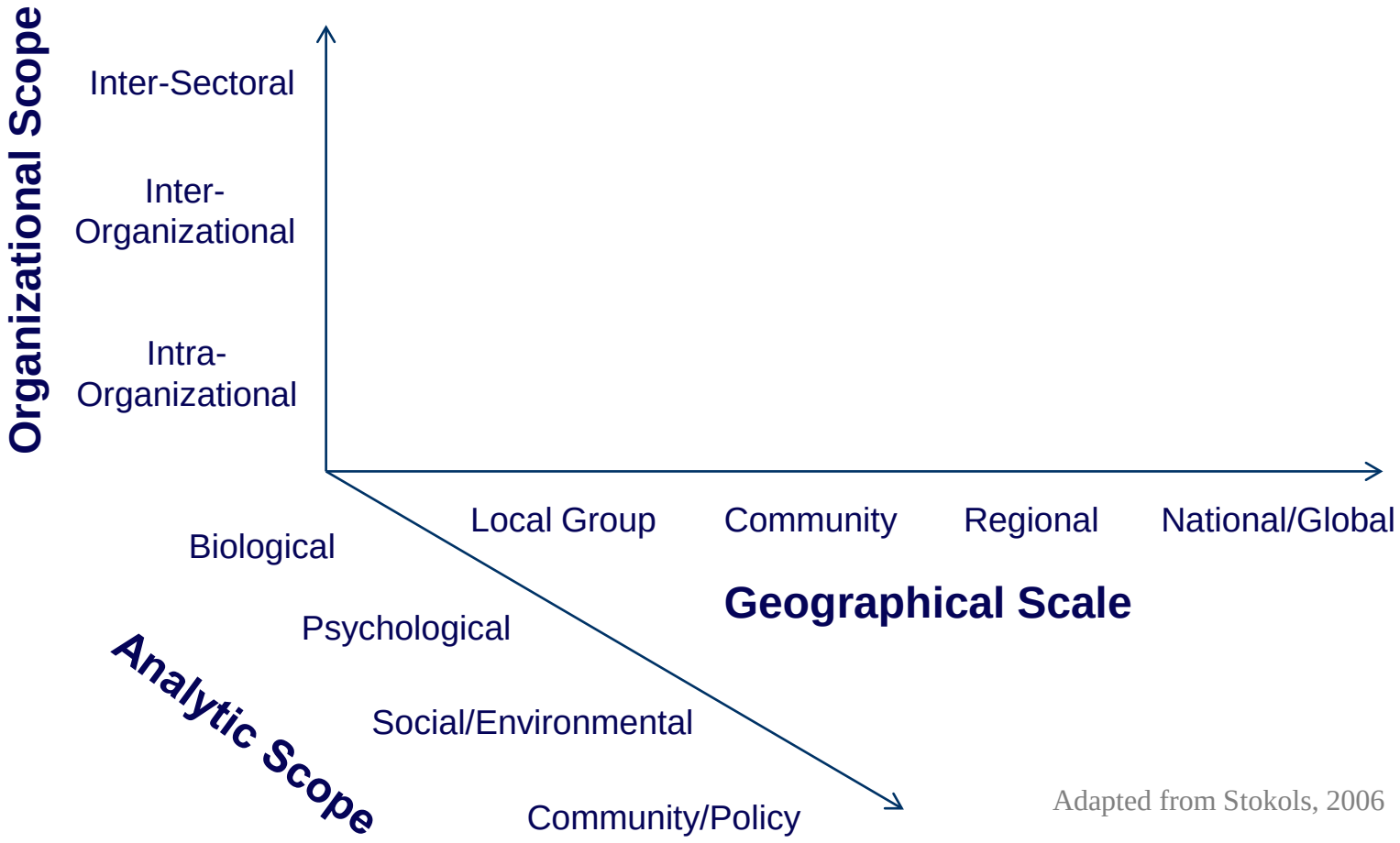
Creates a **wide array of possible profiles** of science teams.

What drives TS and SciTS?

- Ultimately, the **scientific or societal problem** should drive the type of team science, the profile of the science team
  - e.g., the knowledge needed to comprehensively address a scientific problem should drive
    - which disciplines are represented on the team,
    - what levels of analysis are brought to bare,
    - what degree of integration among these approaches should occur.

- The complexity of the team science, of the science teams, drives the **imperative for understanding and applying evidence-based practices and policies.**

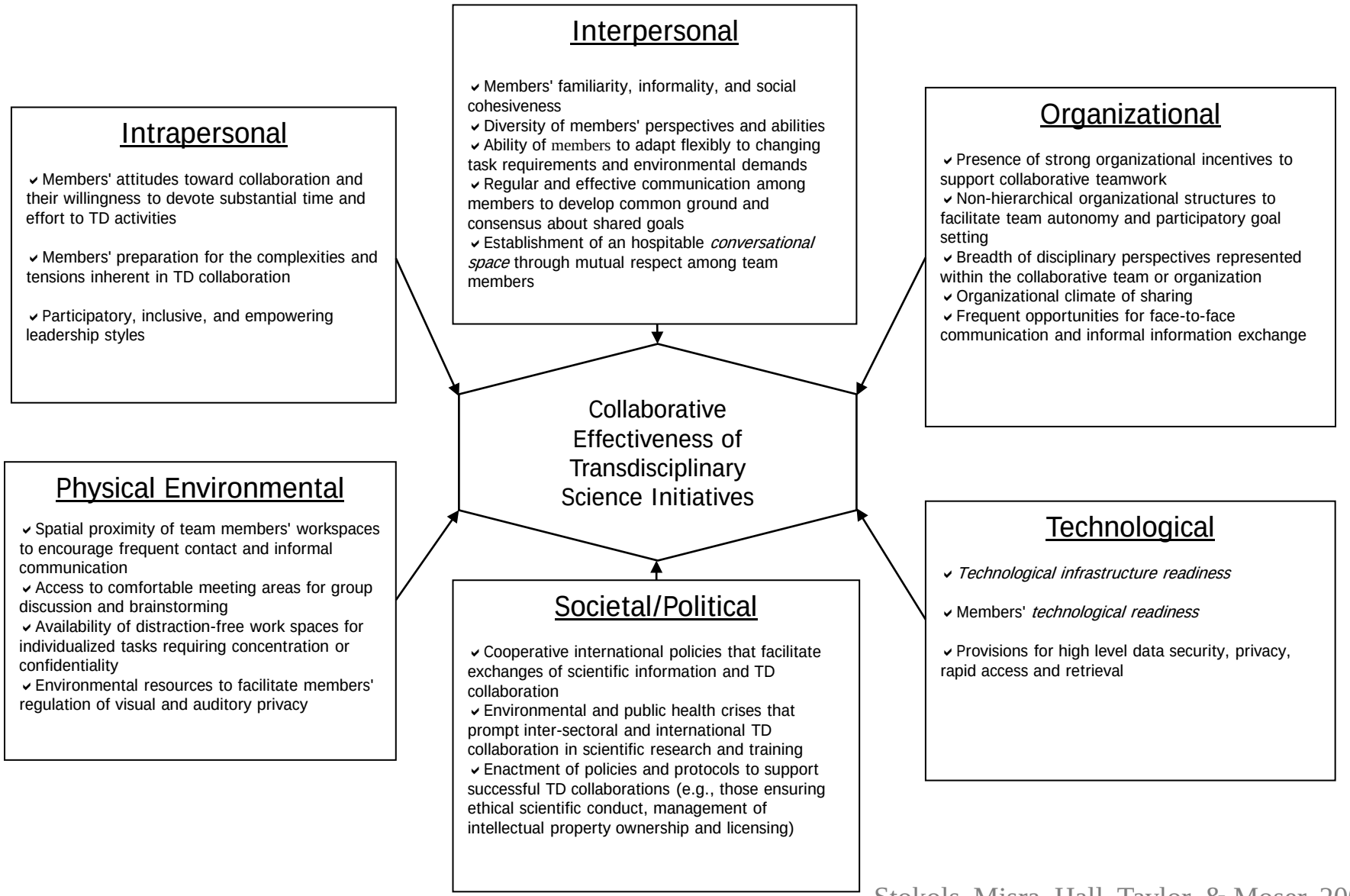
Organizational, Geographic, and Analytic Scope of Team Science



Adapted from Stokols, 2006

COLLABORATION IS COMPLEX

Multi-level contextual factors



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

Team Science Trends

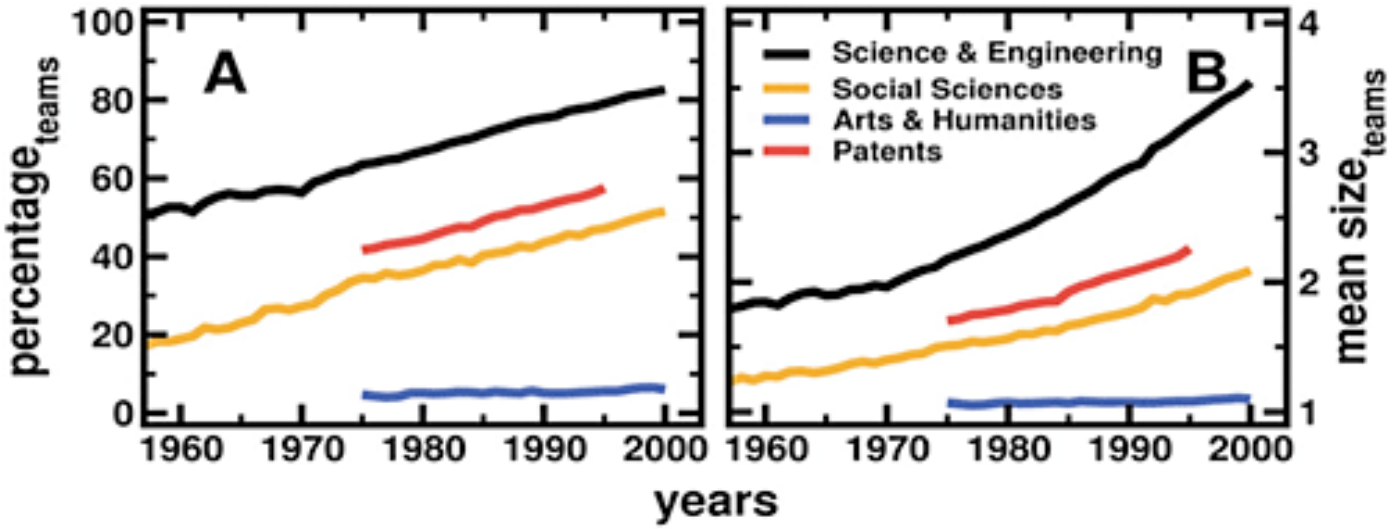
Key empirical findings

TEAMS IN SCIENCE

More of them, greater impact

Number of papers and patents written by team over time

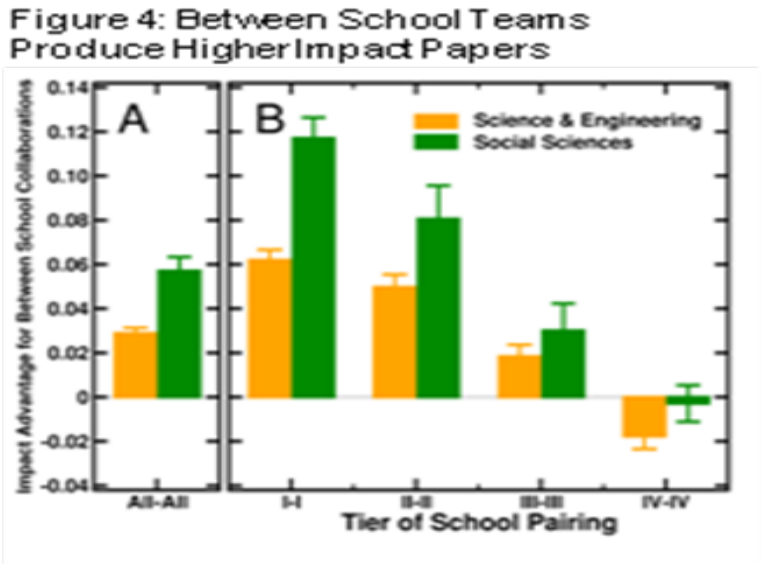
Changes in mean team size over time



- Research is increasingly conducted in teams across virtually all fields
- ~90% of all work in science & engineering disciplines is done in teams
- Teams produce more highly cited research & patents than individuals

Wuchty S, Jones BF, and Uzzi B. The increasing dominance of teams in the production of knowledge. (2007). *Science*, 316(5827), 1036-9.

MULTI-INSTITUTIONAL TEAMS
More of them, greater impact



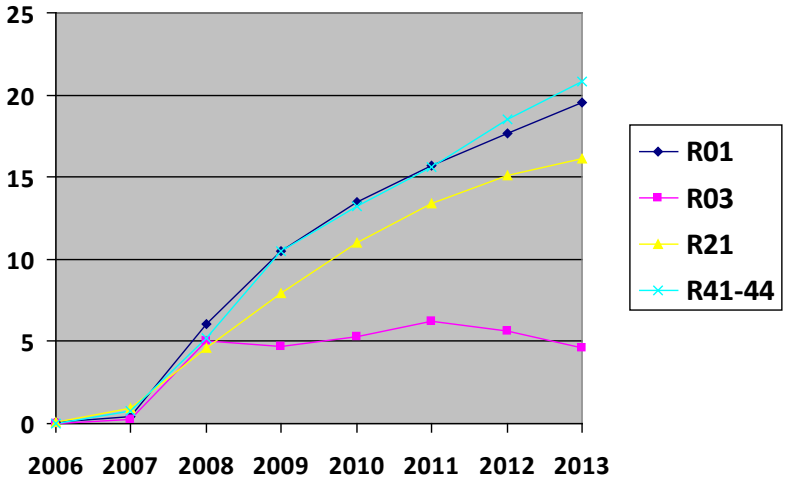
- Multi-university teams increasingly seen in team publications
- Publications by teams of collaborators from **different universities produced higher impact** work than comparable co-located teams or solo scientists

Jones, B., Wuchty, S., & Uzzi, B. (2008). Multi-university research teams: shifting impact, geography, and stratification in science. *Science*, *322* , 5905, 1259-1262.

NIH Funding Trends
Multiple PI Grants

- The multiple PI model was adopted in 2006 in response to –
  - recommendations from the NIH Bioengineering Consortium (BECON), an NIH Roadmap Initiative to stimulate interdisciplinary science, and
  - A directive from the White House Office of Science and Technology Policy (OSTP).
- Allows applicants to identify more than one PI on a single grant application.
- Recognizes that the single PI grant model does not optimally support multidisciplinary collaborations.
- Since 2006, 7,224 multiple PI awards have been funded. The vast majority (81.5%) include two PIs.

Percent of new NIH grants funded by R-mechanisms that use the multiple PI model, 2006-2013



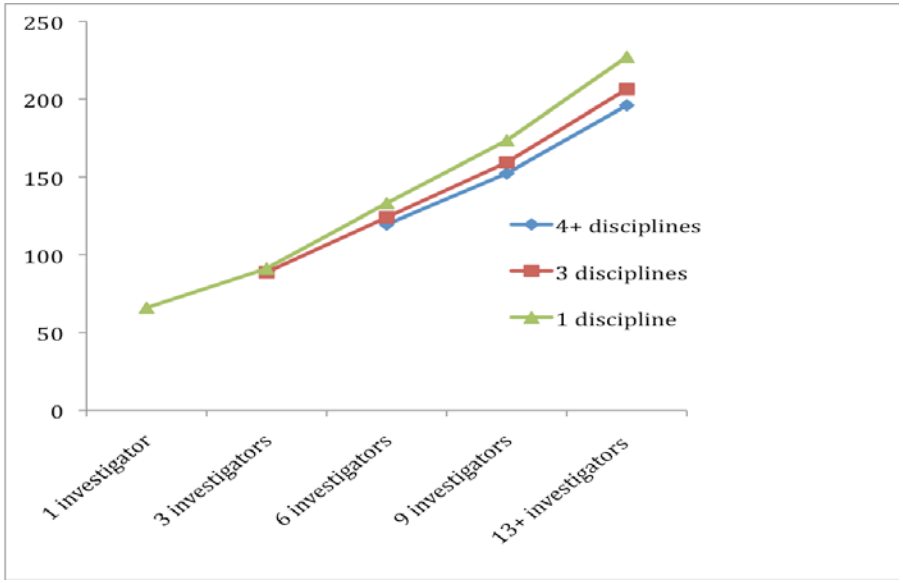
Stipelman BA, Huang, G, Hall KL, Wagner R, Shuptrine SR, Pearson K, et al. An analysis of NIH funding of team-based research grant mechanisms. Poster presented at the Fifth Annual International Science of Team Science Conference, Austin, TX. August 6-8, 2014.

MULTI-DISCIPLINARY PROJECT TEAMS

Lots of investigators & disciplines modulate productivity

Multi-disciplinary Team Science Productivity

Predicted number of publications as a function of both (1) research group size and (2) research group heterogeneity, as measured by number of disciplines represented in the group



Key Finding: In teams of more than three investigators, a higher number of disciplines on the team was associated with fewer publications

Shown are slopes for low and high heterogeneity (low t = 5.23, p < .0001, d = .45; high t = .64, n.s.) The slope in the middle is shown for purposes of illustration: Above 3 disciplines (t = 2.79, p < .01, d = .24), the slopes are not statistically significant.

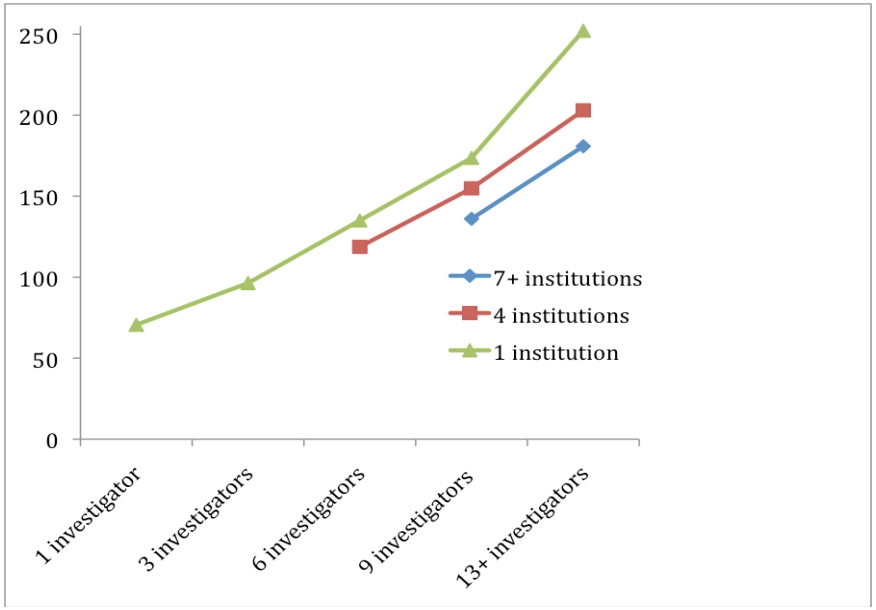
Cummings, J. N., Kiesler, S., Zadeh, R., & Balakrishnan, A. (2013). Group heterogeneity increases the risks of large group size: A longitudinal study of productivity in research groups. Psychological Science, 24(6), 880-890.

MULTI-INSTITUTIONAL PROJECT TEAMS

Lots of investigators & institutions modulate productivity

Multi-Institutional Team Science Productivity

Predicted number of publications as a function of both (1) research group size and (2) group heterogeneity, as measured by number of institutions represented in the group



Key Finding: In teams of six or more investigators, a higher number of institutions on the team was associated with fewer publications

Shown are slopes for low and high heterogeneity (low $t = 4.88$, $p < .0001$, $d = .42$; high $t = .12$, n.s.) The slope in the middle is shown for purposes of illustration. Above 4 institutions ($t = 2.5$, $p = .01$, $d = .22$), the slopes are not statistically significant.

Cummings, J. N., Kiesler, S., Zadeh, R., & Balakrishnan, A. (2013). Group heterogeneity increases the risks of large group size: A longitudinal study of productivity in research groups. Psychological Science, 24(6), 880-890.

A CLOSER LOOK AT "PROJECTS IN THE WILD"
Considerations for enhancing outcomes

- **Multidisciplinary** projects were **superior** to **unidiscplinary** projects in producing **innovative new ideas and fields and new tools** from science

- The projects that used **more coordination mechanisms** also had **more successful outcomes**
  - e.g., direct supervision, face-to-face mechanisms
  - Less coordination especially predicted less training and project outreach

- **Greater number of universities** involved in a collaboration **predicted fewer coordination activities and fewer project outcomes**
  - Dispersed projects that **used more coordination mechanisms** were **more successful** than dispersed projects that used fewer coordination mechanisms

Cummings & Kiesler, 2005, 2007

NCI’s strategies to advance TD team science

Lessons learned from transdisciplinary (TD) initiatives

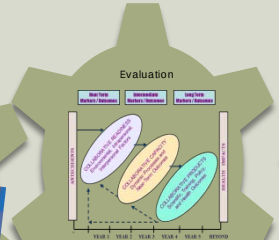
NCI TRANSDISCIPLINARY (TD) CENTER INITIATIVES

*in collaboration with NIDA, NIAAA & RWJF (TTURCs) and NHLBI & OBSSR (CPHHD)

Transdisciplinary Research on Energetics and Cancer Centers (TREC) U54 - $74,811,868

Training and Publications

Phase 1 (2005-2011): Training and career development for 72 new investigators/fellows, over 400 publications, and a mulit-volume Cancer and Energy Balance textbook series.



Centers of Excellence in Cancer Communication Research (CECCR) P50 & P20 - $83,880,445

Centers of Excellence in Cancer Communication Research

CECCR

Evidence-Based Products

ozioma

GOOD NEWS FOR YOUR COMMUNITY

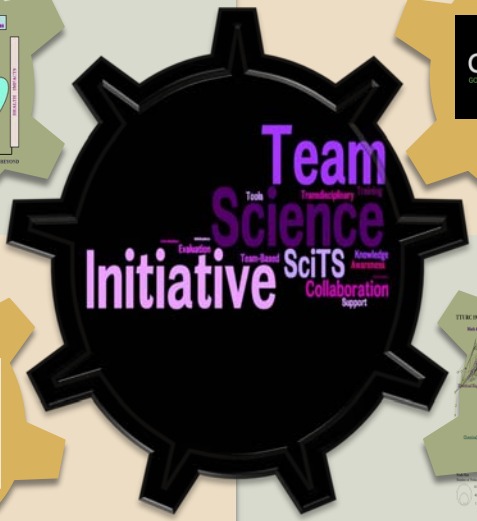
miyo

make it your own

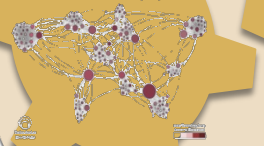
Communicating Science

543 CECCR publications in peer-reviewed journals

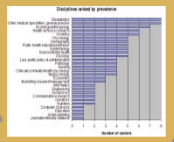
1CECCR-specific journal supplement (*Patient Education and Counseling*)



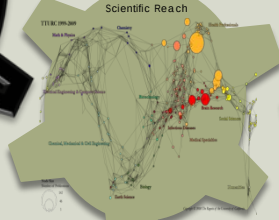
Disciplinary Orientation



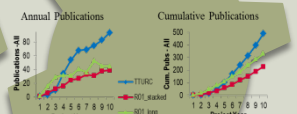
Disciplinary Diversity



Scientific Reach



Research Productivity



Hall et al., 2012

Centers for Population Health and Health Disparities (CPHHD) P50 - $66,298,321

CENTERS FOR POPULATION HEALTH AND HEALTH DISPARITIES

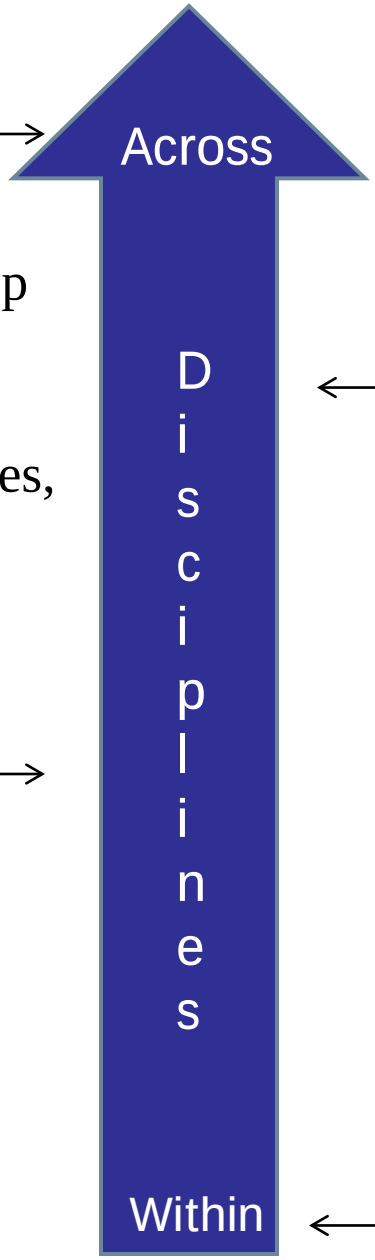
CPHHD

Transdisciplinary Tobacco Use Research Centers (TTURC) P50 - $68,995,753

tturc

Transdisciplinary Tobacco Use Research Centers

A Continuum of Disciplinary Integration



Adapted from Rosenfield, 1992

Transdisciplinary (TD)

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 (MD)

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 (ID)

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 (UD)

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

Continuum of integration – An Analogy

- Unidisciplinary research
- Three cross-disciplinary research orientations
  - Multidisciplinary
    - Independent, Sequential, Divisional
    - Exchange
  - Interdisciplinary
    - Joint, Interactive, Partnership
    - Dialogue, Exchange, Hybridization, Complementary
  - Transdisciplinary
    - Integrative, Interdependent, Immergent
    - Reciprocity, Discourse, Share Vocabulary, Extends

Adapted from Holly J. Falk-Krzesinski, 2012; Austin et al., 2008; Nissani, 1995

TD "INTERVENTION" COMPONENTS TO ADDRESS CONSTRAINTS

Goal: Foster transdisciplinary collaborations to produce science that contributes to reducing the cancer burden

Strategies include:

- **Funding** – provide incentive; ensure special review; FOA language emphasizes TD TS
- **Multiple linked projects/centers** – facilitate within/across center integration
- **Cores/Coordination Center** – provide some "institutional"/administrative support; maximize diverse collaboration; bridging mechanism
- **Steering Committee –** consistent messaging and reinforce TD goals
- **Developmental pilot project funds** – address scientific readiness issues; support "unanticipated" integrative ideas; propel emerging areas of TD research
- **Semi-annual meetings** – foster new collaborations
- **Training** – address needed TD competencies for investigators at multiple career stages
- **Evaluation** – highlight NCI's interest in/focus on collaboration and TD; feedback on progress

NCI Science of Team Science (SciTS) Team

Developing/Supporting the SciTS Field

- Support the development and evolution of the SciTS field via platforms for knowledge sharing, including: web-based technologies, conferences, and journal special issues

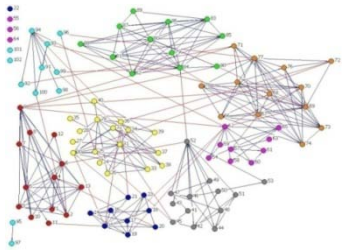
Facilitating/Advancing Team Science Programs and Projects

- Support effective team science through the development of practical tools and resources and funding opportunities

Team Science Toolkit

Studying and Evaluating Team Science Initiatives

- Use innovative multi-method approaches to study the processes and outcomes of cross-disciplinary team science.
- Develop and apply new methods, metrics, definitions, models, and approaches for evaluating cross-disciplinary team science.



NCI SciTS Team Approaches to Study Processes and outcomes of TD TS

- **Study Designs**
  - Quasi-experimental designs
  - Case study
- **Data types**
  - Publications
  - Administrative
  - Participant surveys
  - Interview transcripts
  - Documents
- **Methods/Approaches**
  - Integration of qualitative and quantitative approaches
  - Bibliometric methods
  - Network analysis
  - Data visualization techniques
  - Grantee surveys
  - Grantee interviews
  - Document analysis
  - Peer Review/Expert Judgment
  - Financial Analysis

GRANTEE PERSPECTIVES: TD TS PROCESS

TREC Grantees

Perspectives from Qualitative Study

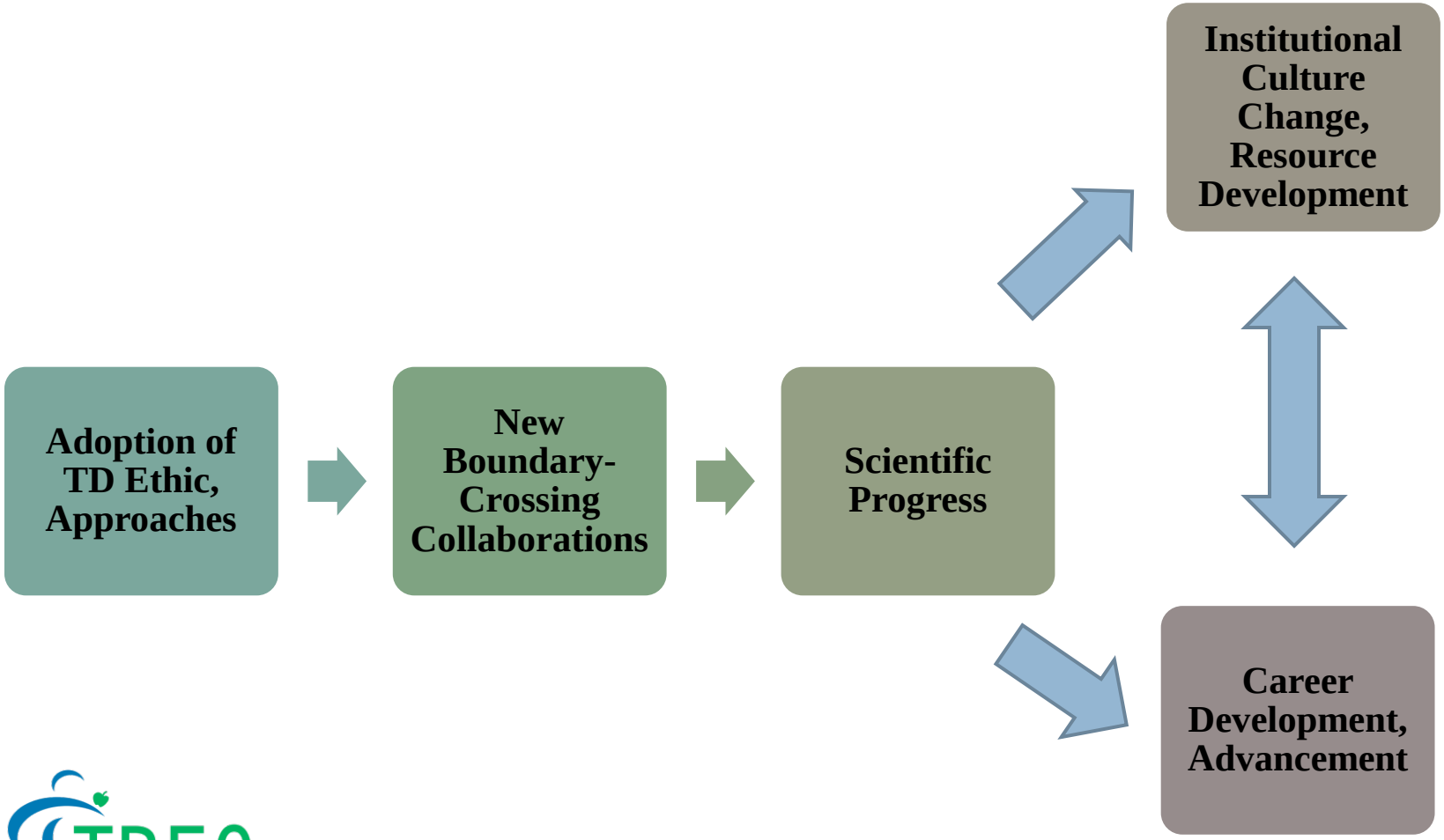
- TREC I Initiative (2005-2010)
  - 4 research centers, 1 coordination center
    - Each center housed 3 -5 R01-sized projects
- Semi-structured interviews with 33 TREC I grantees in 2010

- ***Goal***
  - To foster the TD integration of social, behavioral, and biological sciences to address the intersection of obesity, physical inactivity, poor diet and cancer incidence
- ***Grantees discussed***
  - challenges, facilitating factors, strategies for success, impacts

TREC

Vogel, Stipelman, Hall et al., 2014

Impact of participating in a TD research initiative



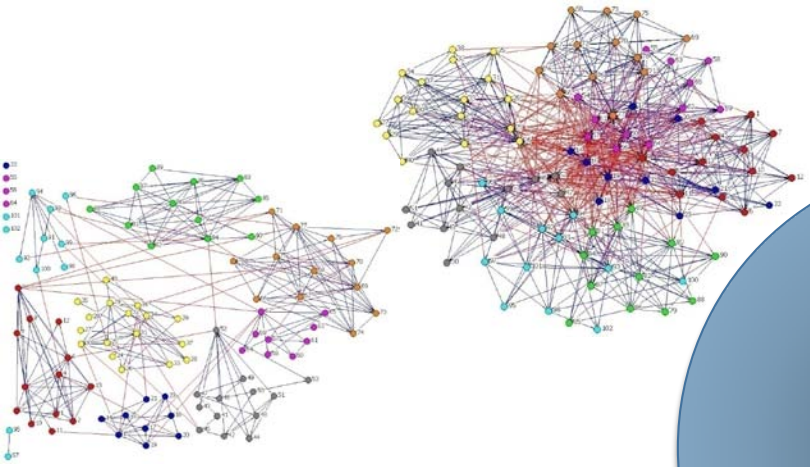
TREC

Vogel, Stipelman, Hall, et al., 2014

Challenges in TD TS

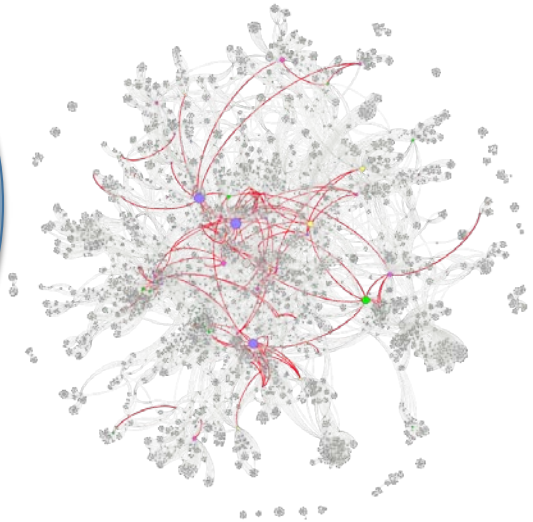
- **Conceptual and Scientific Challenges**
  - Lack of **clarity** about "what TD is" & "how you get there"
  - TD science "**stretches"** investigators' intellectual "capacity" more than UD research
  - TD research is **more complex** than UD research
- **Different Disciplinary Cultures Among Collaborators**
  - Differences in **values, language, traditions**
  - Team members want to stay in their **"comfort zone"** (re: disciplinary culture)
- **Management Challenges**
  - TD research = ***more*** time, resources, planning, and management than UD research
  - **Compromise**, change in routines (e.g., data management)
  - Physical distance = communication challenges, slowed research process
- **Incentive and Recognition Systems and Academic Norms**
  - Academic incentives have **not yet "caught up"** to TD research (e.g., P&T criteria, limited funding opportunities, publishing venues)
  - Colleagues may be **unfamiliar with TD research** (e.g., IRB, grant/manuscript review)

Vogel, Stipelman, Hall et al., 2014



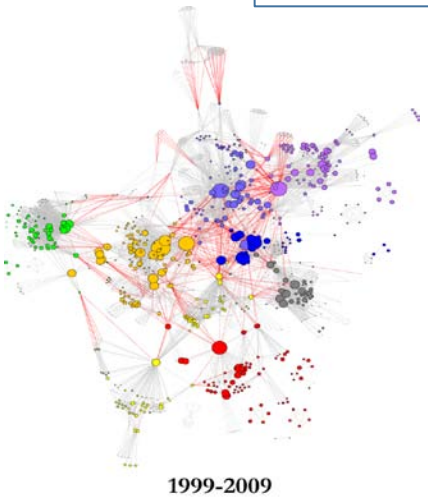
Levels of Analysis

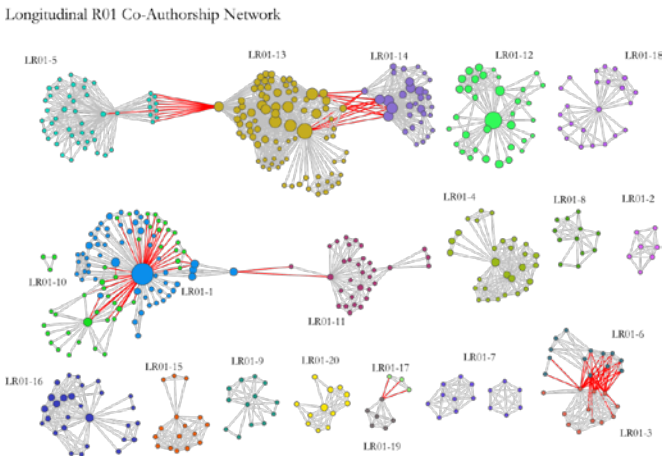
Increased Collaboration



Individuals

Projects and Centers

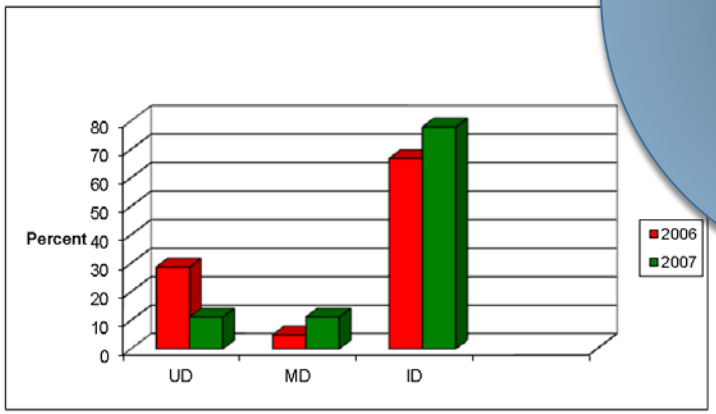




Hall, Stokols, Stipelman, 2012; Gray & Ren, 2007

the initiative ***"transformed"*** their attitudes about TD research, and the ways they conduct their research

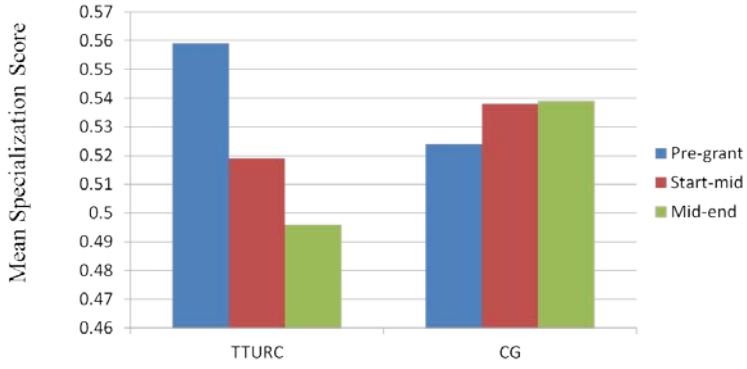
TD ETHIC



Key finding: Increase in cross-disciplinary integration of proposals from year 2 to 3
Method: Content analysis of pilot grant proposals developed during initiative

MORE INTERDISCIPLINARITY

Increased Integration



- Demonstrates decreases in specialization for TTURCs (increase in diversity of where work is published)

LESS SPECIALIZATION

research is more **sophisticated, complex, and "holistic"** than their pre-TD initiative research

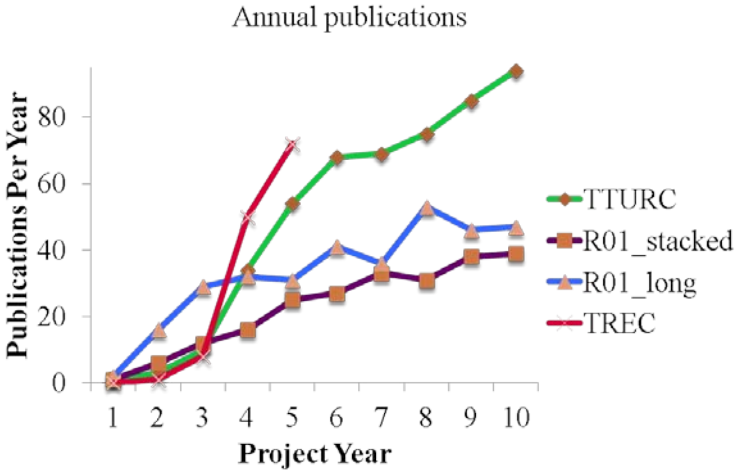
COMPLEX & HOLISTIC

Hall, K.L., Stokols, D., Moser, R., et al., 2008; Hall, Stipelman, et al., 2009; Vogel, Stipelman, Hall et al., 2014

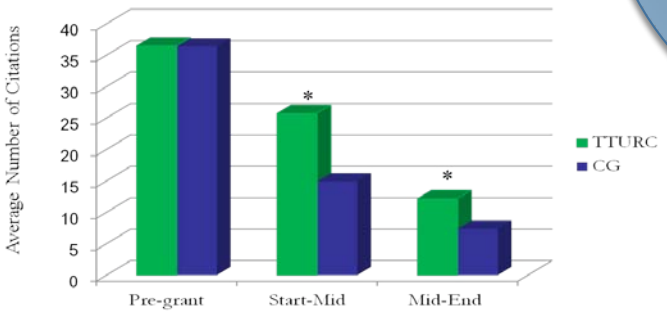
Led to important findings in previously unexplored areas of science

SCIENTIFIC PROGRESS

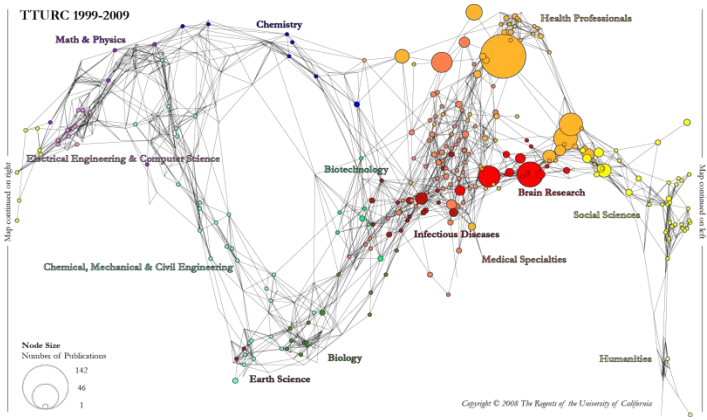
Increased Productivity and Progress



MORE PUBLICATIONS



INCREASED CITATIONS



WIDER REACH/BREADTH

Hall, Stokols, Stipelman, et al.,2012; Vogel, Stipelman, Hall et al., 2014;Stipelman, Hall, Zoss, et al., 2014

Facilitating Factors and Strategies for Success in TD TS

- **A "TD Ethic"**
  - "***Critical awareness***" of strengths and weaknesses of all disciplines
  - Belief in ***added value*** of TD TS
  - "O***penness***" to exploring other areas of science – feeling "enriched" by this approach
- **Team Processes**
  - Articulating **concrete shared goals** (grants, papers)
  - Developing mutual understanding of one another's disciplinary values, norms, approaches
- **Funding agency expectations** for TD integration -- FOA and throughout
- **TREC structure supported new collaborations**
  - "Developmental Pilot Project" funds, semi-annual all-grantee meetings, cross-center working groups, training opportunities
- **Center directors and senior investigators** created environment conducive to TD collaboration
  - Provided **vision**, acted as **matchmakers**, championed TD at the institution, obtained **resources** for TD science
- **Biostatistics core staff** integrated disciplinary approaches
- **Trainees** introduced innovations, ***bridged*** projects within and across centers

Vogel, Stipelman, Hall et al., 2014

Enhancing Team Science

- **Overall we found increases in:**
  - **Integration** (e.g., TD ethic, orientation, and approaches; decrease in specialization)
  - **Collaboration** (i.e., across individuals, projects/centers, levels of analysis)
  - **Productivity** – (number of publications over time)
  - **Reach** - (e.g., spread across map of science, new journals and conferences)
  - **Impact** (e.g., impact factor, citations)

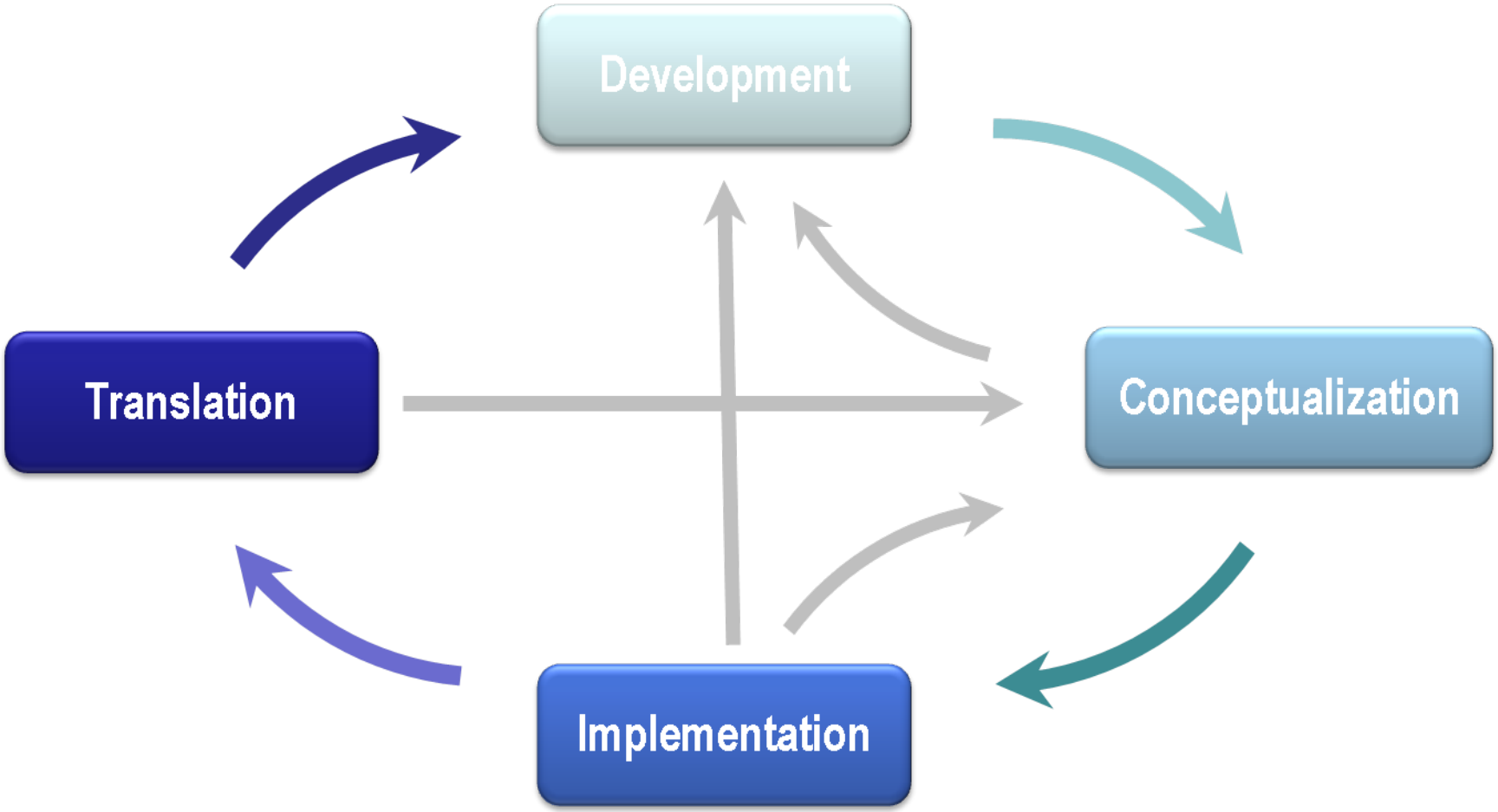
- **We believe these findings help to illustrate:**
  - Added value of TD research (e.g., based on above)
  - With structures in place to help mitigate cultural and structural barriers, we can enhance the way investigators conduct research, engage in collaboration, and advance science

- **Build on emerging evidence and lessons learned** to most effectively and efficiently advance our science
  - There are conceptual models, practical strategies, and resources to help guide and support the conduct of research at the team, center, and initiative levels

Four Phase Model for TD TS

A roadmap for planning, implementation, quality improvement

Four Phase model of transdisciplinary team science



Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine, 2* (4).

Development Phase: Goals and Key Processes

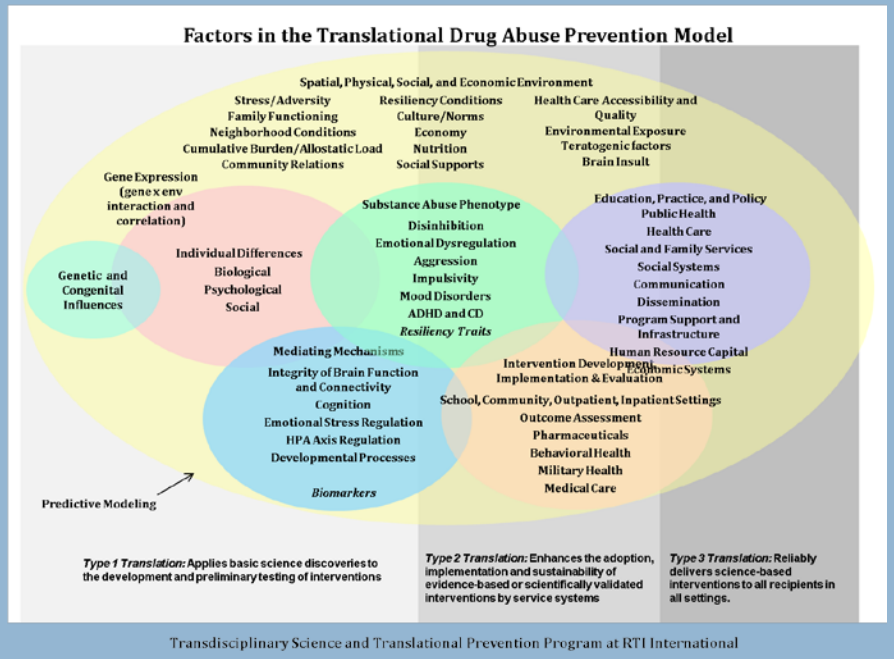
Goal: Define the scientific or societal **problem space** of interest, including identifying the intricacies and interconnections of concepts that fall within the problem space and establishing the boundaries of the problem space to be addressed.

Key Processes: Encourage information sharing and integrative knowledge creation among diverse participants

- Generate **shared mission** and goals
- Develop **critical awareness**
- **Externalize group cognition**
- Developing group environment of **psychological safety**

Team Type:

Network, working group, advisory group, emerging team



Transdisciplinary Science and Translational Prevention Program at RTI International

Engage in a group process to define a TD problem space by collaboratively generating a cognitive artifact that helps to articulate the complexities of the problem space and the wide variety of relevant disciplines and fields.

Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine*, *2* (4).

Conceptualization Phase: Goals and Key Processes

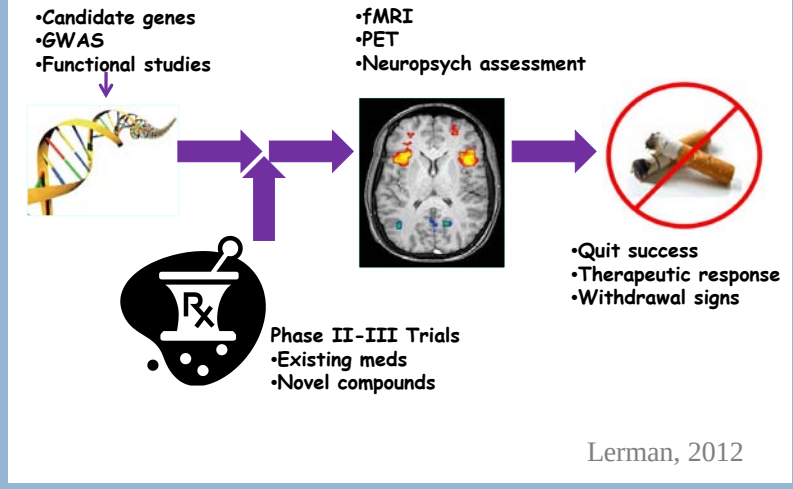
Goal: Develop novel research questions, hypotheses, a conceptual framework, and a research design that integrate collaborators' disciplinary perspectives and knowledge domains to address the target problem in innovative ways.

Key Processes: Facilitate integrative knowledge creation among team members and the development of a research plan

- Create **shared mental models**
- Generate **shared language**
- Develop **compilational transactive memory**
- Develop team **TD ethic**

Team Type:

Emerging team, evolving team



Use public seminars among collaborators to help develop compilational transactive memory, shared language for a TD research collaboration, team TD ethic, and shared mental model of research collaboration.

Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine, 2* (4).

Implementation Phase: Goal and Key Processes

Goal: Launch, conduct, and refine the planned TD research

Key Processes:

Developing a shared understanding of…

-**who *knows* what** (compilational),

-**who *does* what** (compositional),

-**how things get done** (taskwork), and

-**how interactions occur** among the research team (teamwork)

- Compositional, Taskwork, and Teamwork Transactive Memory
- Conflict Management
- Team Learning (e.g., reflection, action, feedback, discussion)

Team Type:

Real team

"Real" vs "Psuedo" team

Characteristics that lead to increased performance and innovation

- Interdependent
- **Iterative reflection** (systematic consideration of team performance and participation in related adaptation to team goals and processes)
- Demonstrate clear understanding of team membership

West et al, 2011; West & Lyubovikova, 2012

Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine, 2* (4).

Translation Phase: Goals and Key Processes

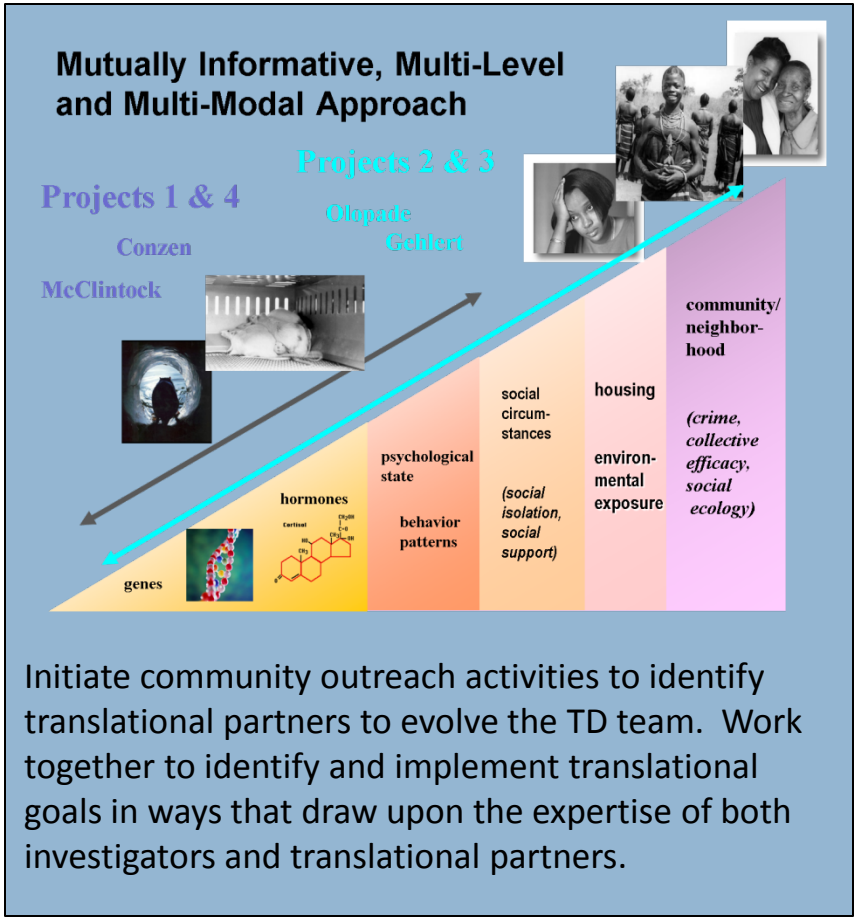
Goal: Apply research findings to **advance progress along the discovery–development–delivery pathway** to ultimately provide innovative solutions to real-world problems.

Key Processes:

- The **evolution of the team**, as needed, to identify and pursue translational goals
- Develop **shared goals** for the translational endeavor
- Develop **shared understandings** of how these goals will be pursued

Team Type:

Adapted team, new team



Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine, 2* (4).

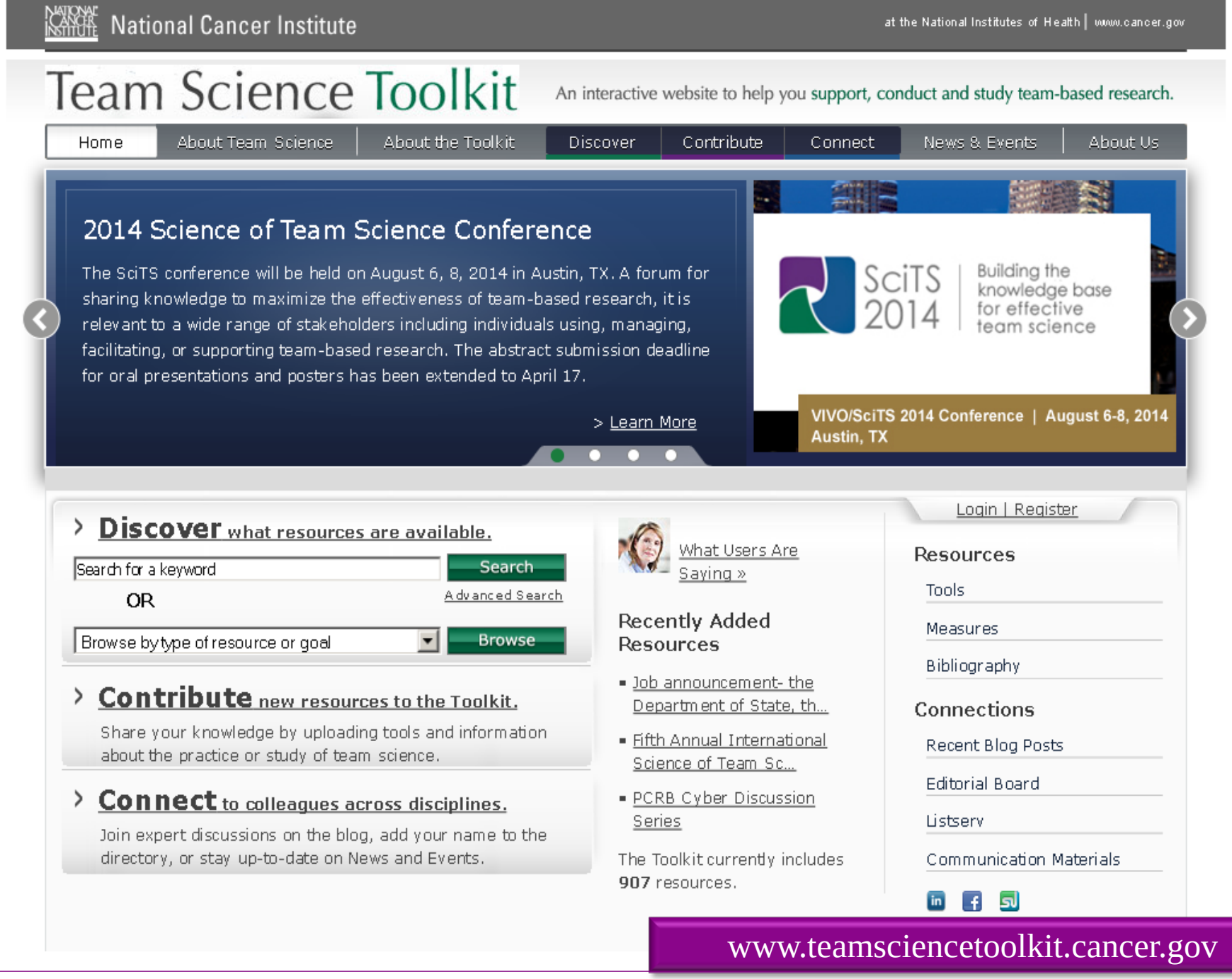
Implications of the Four-Phase Model

- For funders and initiative leadership --
  - Highlights **key benchmarks** that can be supported via multiple levers: RFA language, initiative leadership, training opportunities, coordination center activities, working groups activities, developmental funds
  - Highlights potential **gaps in funding support,** by phase of research

- For investigators--
  - Serves as a prototype or **heuristic**, a "roadmap" that can **guide team processes** – initiative level, center level, project level
  - Can support planning, implementation and **quality improvement** activities
  - May help to **focus limited time/resources** on key benchmarks

The Team Science Toolkit

An online “one-stop-shop” for resources to support successful TS



www.teamsciencetoolkit.cancer.gov

The Team Science Toolkit is an interactive website that provides resources

A "One-Stop Shop" for Team Science

- **Consolidates information** on team science and the SciTS field in one accessible location
- **Integrates resources** from multiple disciplines and fields, e.g., psychology, management, public health, communications
- Includes a user-generated set of resources, e.g. **practical tools** and strategies for TS, **measures and metrics** for studying TS, bibliographic citations and **publications**
- Includes sections curated by the NCI, e.g. **expert blogs**, key resources about TS and the SciTS field

How to use the Team Science Toolkit

Discover:

- Learn from colleagues by exploring Toolkit resources contributed by other users
- Download resources that can support your team science goals

Contribute:

- Share your knowledge of team science and the Science of Team Science
- Upload resources such as: documents, links, information, or comments on resources already in the database

Connect:

- Connect with colleagues who share your interests in team science via our expert blogs, news and events bulletin boards, expert directory and listserv

How Can the Toolkit Help You?

If you are:	And you want to:	Use the Toolkit to find resources such as:
An **investigator** using team science approaches	**Find practical tools and strategies to help support successful team science projects**	• Publications on effective team science approaches • Model "prenuptial agreements" for new collaborations • Strategies for team communication and data sharing • Training resources to build team science competencies
A **team science evaluator or scholar**	**Evaluate or study** team science processes, outcomes, and contextual influences	• Survey instruments and interview guides • Measures, metrics and algorithms • Reliability, validity and scoring methods
An **administrator** at an academic institution, business, or other organization	**Support team science approaches and scholarship** at your institution	• Promotion and tenure policies recognizing team science • Collaboration techniques to bridge departments and organizations
A **funding agency official**	**Provide support** for team science	• Funding announcements • Protocols for data sharing and co-authorship

Practical Tools for TS

Find them on the Team Science Toolkit!

Reducing Conflict

Pre-collaboration agreement (aka "Prenup for scientists")

- Offers discussion questions to help collaborators commence a project by anticipating, discussing, and resolving possible areas of disagreement common to may collaborations.
- Helps them define expectations related to goals, roles, products, authorship, etc.

Example Questions:

- What are the expected contributions of each participant?
- What will be the **mechanisms for routine communication** among members of the research team (to ensure that members are kept informed of relevant issues)?
- What will be the **criteria and the process for assigning authorship** and credit?
- When and **how will you handle intellectual property and patent applications**?
- How and by whom will data be managed? How will access to data be managed? How will you handle **storage and access to data** after the project is complete?

www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=53

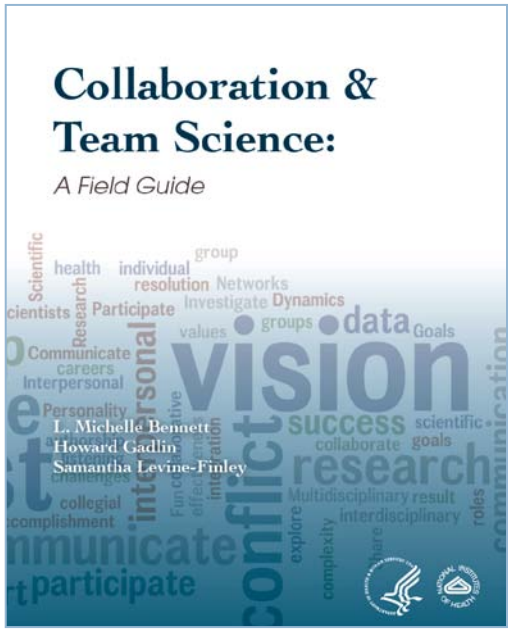
GUIDANCE FOR THE TS PROCESS

Collaboration and Team Science: A Field Guide

Bennett L.M., Gadlin H., and Levine-Finley S. (2010)

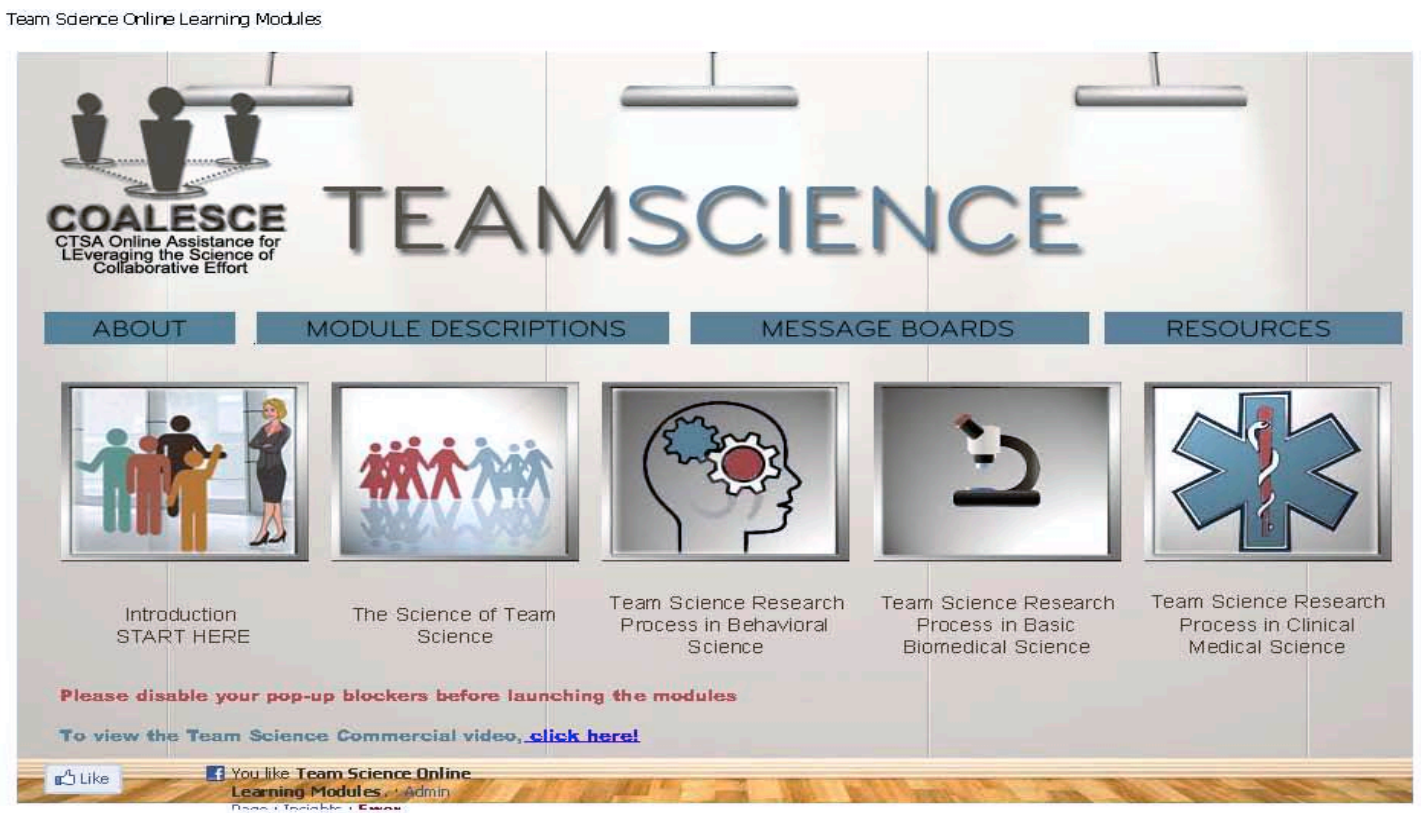
Partial Table of Contents --

- ….Building a Research Team
- Fostering Trust
- Developing a Shared Vision
- Communicating About Science
- Sharing Recognition and Credit
- Handling Conflict
- Strengthening Team Dynamics
- Navigating and Leveraging Networks and Systems
- Challenges….
- References and Additional Resources
- Appendix: Collaborative Agreement Template



www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=267

Developing Skills for Team Science



NUCATS
CLINICAL AND TRANSLATIONAL SCIENCES INSTITUTE

Supported in part by: CTSA grant 3UL1RR025741 Multidisciplinary Clinical and Translational Science Program (PI: Philip Greenland) and National Library of Medicine contract N01-LM-6-3512 from the Office of Behavioral & Social Sciences Research, (PI: Bonnie Spring)

NORTHWESTERN UNIVERSITY

http://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=395/

Improving Cross-Disciplinary Communication

The Toolbox Project provides **a philosophical yet practical enhancement to cross-disciplinary, collaborative science.**

Rooted in philosophical analysis, Toolbox workshops **enable cross-disciplinary collaborators to engage in a structured dialogue about their research assumptions**. This yields both self-awareness and mutual understanding, supplying collaborators with the robust foundation needed for effective cross-disciplinary, collaborative research.

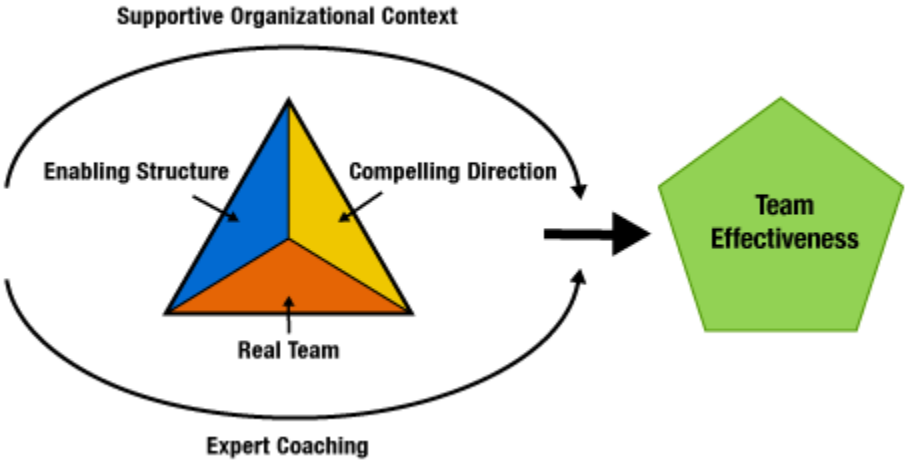
The Toolbox Project offers **facilitated workshops** to **help teams examine the key dimensions of their collaboration and communication** from a philosophical perspective.

https://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=402

Diagnostics to Enhance Team Collaboration

"Team Diagnostics" Survey

- Online diagnostic survey **completed by all team members.**
- Generates a **summary report diagnosing team's strengths and weaknesses**
- Based on Richard Hackman's authoritative book, "Leading Teams"(2002), the survey **assesses teams on five "conditions of effectiveness"**
- No cost to users, data belong to developers.



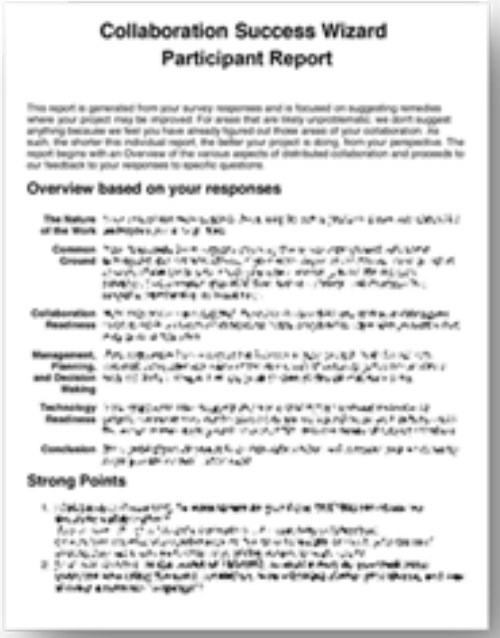
www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=60

Diagnostics for Enhancing Distance Collaborations

Online **diagnostic survey** for geographically distributed collaborations.

Probes **factors that may strengthen or weaken the collaboration**.

Provides both personal and project-level reports to help **build successful and productive collaborative projects**.


Collaboration Success Wizard
Participant Report

Overview based on your responses

Strong Points

http://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=773

Guidelines For Interdisciplinary Hiring, Promotion And Tenure Decisions

Traditional scholarly **recognition and reward systems tend to favor disciplinary expertise and experience over interdisciplinary successes**. At the same time, many important research questions require integration of multiple perspectives.

Recognizing the need to develop better means of recognizing faculty work that does not match standard disciplinary/departmental criteria, **some institutions are adopting new guidelines for hiring, promotion, and tenure decisions.**

This report was developed by the Council of Environmental Deans and Directors of the NCSE (National Council for Science and the Environment), to help **guide individuals and institutions navigating this transition in academic reward systems.**

https://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=266

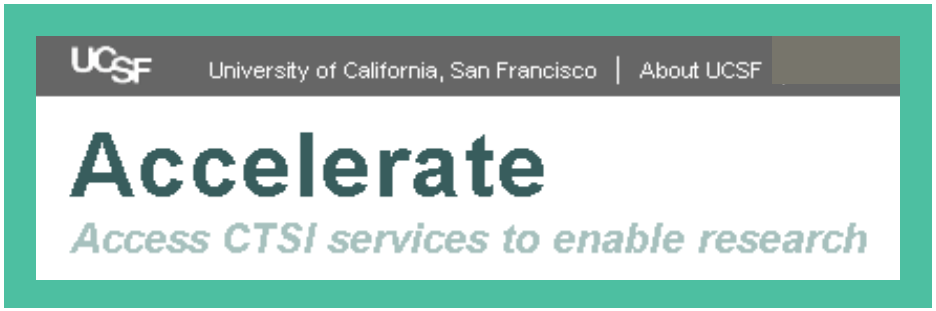
Recognition and Rewards for Team Science

UNC School of Medicine Tenure and Promotion Policy

- While the evaluation of accomplishments in research, clinical scholarship, and educational **scholarship has traditionally focused on a faculty member's individual achievements** (e.g., first and senior authorships, funding as the principal investigator on grant awards, invitations to make presentations on national or international forums, etc.), **it has become increasingly clear that the present and future of biomedical science is placing more and more emphasis on interdisciplinary team activities.**
- Therefore, when relevant, a faculty member's **contributions to interdisciplinary teamwork will be given careful consideration**.
  - Factors such as **originality, creativity, indispensability, and unique abilities** will be considered when making this evaluation.
  - The candidate is expected to include in the promotion packet a **description of his/her role in the overall activities of the team.**
  - The departmental review process will include a **solicitation of information** regarding the candidate from the **director of the project, the principal investigator, as well as any others** who have first-hand knowledge that would clarify the candidate's role in the overall team effort.
  - Finally, the **Chair's letter must spell out such collaboration(s) in considerable detail**, especially if interdisciplinary team activities are felt to be an important aspect of the case being made for the specific promotion.

http://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=1521

Guidance For Academic-Industry Partnerships



Alliances between universities and industry are playing an increasing role in facilitating cutting-edge basic and clinical research. Yet faculty are not trained to navigate these relationships.

This web resource **helps new and established faculty understand how to engage in alliances with companies**, protect their research/publication rights and intellectual property, and avoid conflict of interest when consulting for companies. It **answers common questions**, and **points users to other informative websites and experts** who can provide more detailed support.

http://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=750

External Rewards and Recognition

This **annual award was established by AACR and Eli Lilly to incentivize and reward interdisciplinary team science in cancer research**, by recognizing teams of scientists that have made important contributions, and their institutions.

The award is **presented at the AACR annual meeting**, during the opening ceremony. The team selected to receive the reward receives a **substantial financial award** and the **represented institutions are recognized** at the meeting for actively foster interdisciplinary team science.

https://www.teamsciencetoolkit.cancer.gov/public/TSResourceTool.aspx?tid=1&rid=54

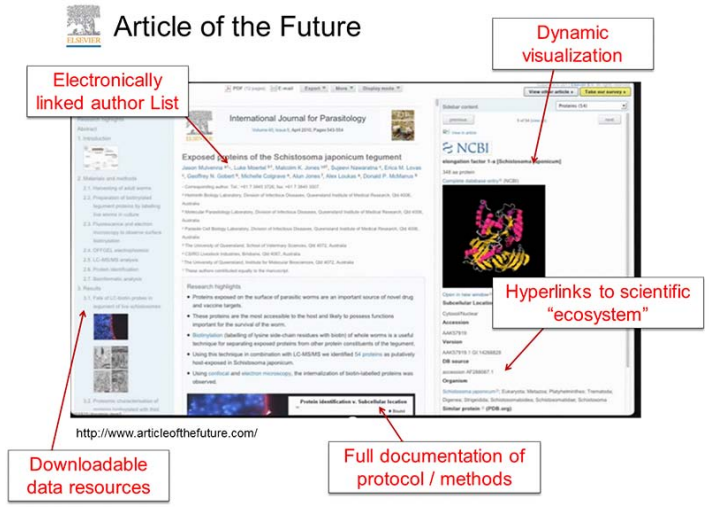
Invited Expert Bloggers

"Inreach" and the Interdisciplinary Executive Scientist:
The missing puzzle pieces for effective interdisciplinary research

In this blog, the first in our "Voices from the Field" series, Dr. Christine Hendren makes the case for a new professional role – that of Interdisciplinary Executive Scientist – to facilitate effective interdisciplinary collaboration in large teams.

Christine Ogilvie Hendren PhD, Executive Director and Research Scientist, Center for the Environmental Implications of NanoTechnology (CEINT), Duke University

Can Principles of Effective Team Science Promote More Robust and Reproducible Research?



Dr. Bradford Hesse discusses challenges to transparency and reproducibility in science, and identifies potential ways that innovations in web-based publishing can lead to more robust and reproducible science, and ultimately, more useful and impactful findings.

Bradford W. Hesse PhD, Chief, Health Communication and Informatics Research Branch, Behavioral Research Program, National Cancer Institute

Extensive Bibliography

Over 2000 related articles

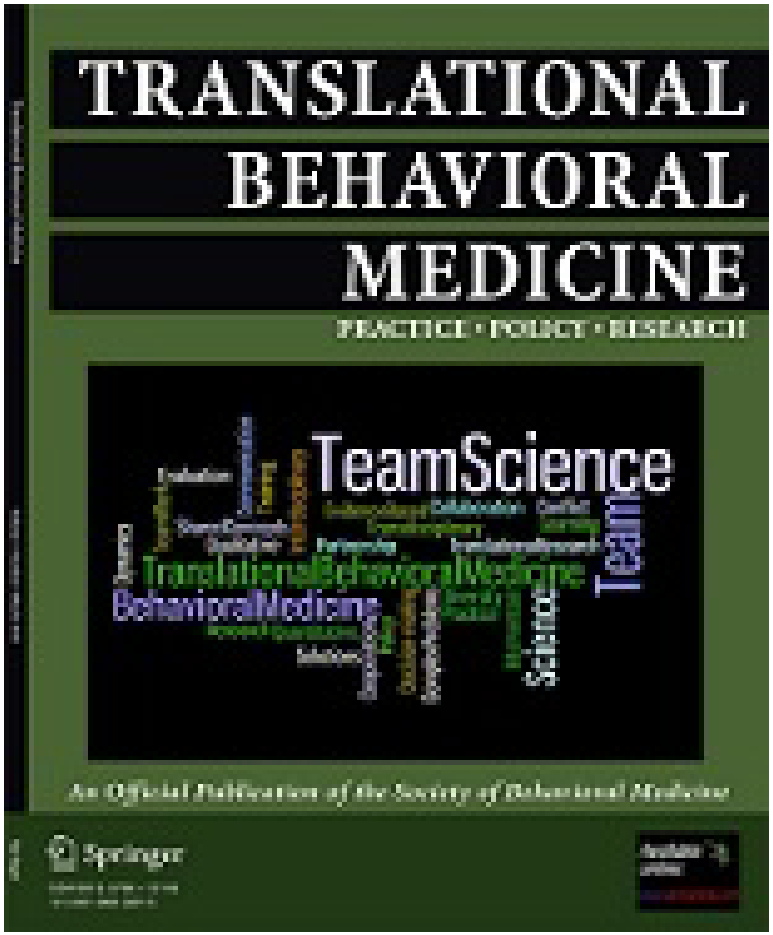
Early Set of Go-To Articles
Launched the SciTS Field

Provides an overview of key research and conceptual developments in the SciTS field, 2008

The most highly cited and downloaded AJPM supplement in the past two decades.

Two of the articles were among the top 15 most highly cited articles in AJPM, contributing to the journal's impact factor for 2010.

TEAM SCIENCE SPECIAL ISSUE
Showcased Growing Evidence Base



<u>Title</u>: Team Approaches to Science, Practice and Policy (2012)

<u>Editors:</u>
Bonnie Spring, PhD, Northwestern University
Holly Falk-Krzesinski, PhD, Northwestern University
Arlen C. Moller, PhD, Northwestern University
Kara Hall, PhD, National Cancer Institute

Spring, B., Hall, K.L., Moller, A., & Falk-Krzesinski, H. (2012). An emerging science and praxis for research and practice teams. *Translational Behavioral Medicine, 2* (4).

Hall, K.L., Olster, D, Stipelman, B., &Vogel, A.L. (2012). News from NIH: resources for team-based research to more effectively address complex public health problems. *Translational Behavioral Medicine, 2* (4).

Hall, K.L., Vogel, A.L., Stipelman, B., Stokols D., Morgan, G., & Gelhert, S. (2012). A Four-Phase Model of Transdisciplinary Research: Goals, Team Processes, and Strategies. *Translational Behavioral Medicine, 2* (4).

Vogel, Amanda, Feng, A., Oh, April, Hall, K.L., Stipelman, B., Stokols, D., Perna, F, & Nebeling, L. (2012). Influence of a National Cancer Institute Transdisciplinary Research and Training Initiative on Trainees' Research Attitudes, Approaches and Productivity. *Translational Behavioral Medicine, 2* (4).

LATEST SPECIAL ISSUE
Authors include Experts in Teams and TS

Special Issue: Collaboration Science and Translational Medicine, 2014

Editor:
Gaetano R. Lotrecchiano, EdD, PhD
George Washington University
School of Medicine and Health Sciences

12 papers on team science in cross-disciplinary and translational research.

Vogel, A.L., Stipelman, B.A., Hall, K.L., Stokols, D., Nebeling, L., & Spruijt-Metz, D. **Pioneering the transdisciplinary team science approach: Lessons learned from National Cancer Institute Grantees.** *J Trans Med and Epi.* 2(2): 1027.

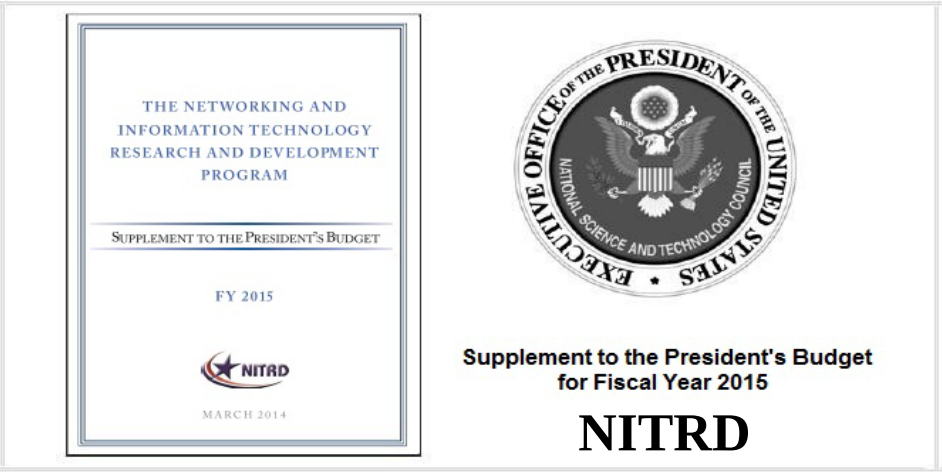
Gehlert, S., Hall, K.L., Vogel, A.L., Hohl, S., Hartman, S., Nebeling, L., Redline, S., Schmitz, K., Thornquist, M., & Thompson, B. **Advancing transdisciplinary research: The Transdisciplinary Research in Energetics and Cancer Initiative.** *J Trans Med and Epi.* 2(2): 1032.

Stipelman, B.A., Hall, K.L., Zoss, A., Okamoto, J., Stokols, D., and Borner, K. **Mapping the impact of transdisciplinary research: A visual comparison of investigator-initiated and team-based tobacco use research publications.** *J Trans Med and Epi.* 2(2): 1033.

Emerging and Future Directions

NITRD Collaboration Planning
NAS Consensus Study
Comprehensive Systems Map for Team Science
NIH SciTS 2015 Conference

TRANS-AGENCY FEDERAL WORKING GROUP ON TS



The NITRD Program (Networking and Information Technology Research and Development Program) provides a framework in which many federal agencies come together to coordinate their networking and information technology (IT) research and development (R&D) efforts. NITRD is located within the White House Office of National Science and Technology Policy (OSTP).

Team Science is of particular interest, given the **prevalence of virtual collaboration** (i.e., computer mediated collaboration). Led to creation of subcommittee on this topic.

https://www.teamsciencetoolkit.cancer.gov/Public/TSResourceTool.aspx?tid=1&rid=1518

TRANS-AGENCY FEDERAL WORKING GROUP ON TS

- NITRD -- Social, Economic, and Workforce Implications of IT and IT Workforce Development (SEW) Coordinating Group
  - Subcommittee on Collaboration and Team Science
- Trans-agency membership
  - NIH, NSF, NASA, DOE, DOJ, EPA, USDA, and others
- Committee Co-chairs
  - Kara Hall (NIH), Kevin Crowston (NSF)
- Goal
  - To launch a series of topical meetings to enhance understanding of and support for collaboration in science
- Focus
  - Evidence-based practical tools to support effective collaboration in science

https://www.nitrd.gov

TRANS-AGENCY COLLABORATION TO DEVELOP COLLABORATION PLAN GUIDANCE

Vision: Advance science through successful collaboration.

Goal: Help researchers put in place the processes and infrastructure needed to facilitate a successful team-based initiative.

Objectives: Develop guidance for:

- *Researchers* - key components for investigators to consider when developing collaboration plans
- *Reviewers* – evaluation criteria for reviewers of collaboration plans submitted by investigators as part of a funding proposal
- *Agencies* – recommended language for program officers to use when (1) soliciting collaboration plans from investigators (e.g., in FOAs); or (2) giving guidance to investigators preparing or engaged in a collaborative project

INITIAL PRODUCT (in Development)

- Rationale for Collaboration Plans
  - Poorly managed TS collaboration may negatively impact the quality of the science, while well managed collaborations have greater potential to foster innovation, creativity, and productivity
- Draft developed over the course of a year (2014-2015) through a series of workshops, including:
  - Scholars from relevant fields
    - SciTS, Teams, Management, Organization Sciences
  - Agency Representatives
    - Program officials, Policy officials, Program Managers, Agency Ombudsman
- Dissemination:
  - Collaboration planning guidelines for agencies
  - Peer review publication describing relevance to investigators, reviewers, and funding agencies

10 Components for Collaboration Planning

1. Rationale for Team Approach & Configuration
2. Collaboration Readiness (Individual, Team, Institutional)
3. Technological Readiness (Individual, Team, Institutional)
4. Team Functioning
5. Communication & Coordination
6. Leadership, Management, & Administration
7. Conflict Prevention & Management
8. Training
9. Quality Improvement Activities
10. Budget & Resource Allocation

How to Write a Collaboration Plan

Why Plan for Collaborations?

Science is becoming increasingly collaborative, and frequently involves multiple investigators, institutions, disciplines, and fields. Such collaborations often are able to address more complex and sophisticated research problems, by integrating the expertise and resources of multiple collaborators. But they also involve a number of costs, most particularly management complexities, including additional attention to planning for and facilitating effective team functioning, and preventing or addressing challenges specific to teamwork that can threaten the success of the initiative. Poorly managed collaboration may negatively impact the quality of the science, whereas well managed collaborations have the potential to foster innovation, creativity, and productivity.

To help enhance the success in scientific collaborations, funding agencies may ask investigators to submit "collaboration plans" as part of their funding applications, just as they ask investigators to submit research plans. Collaboration plans may benefit any scientific endeavor that includes two or more investigators working together. Though as a proposed scientific collaboration grows in scope and size, such plans become increasingly important.

Summarizing the State of the Science, and Identifying Future Directions

- **NAS Consensus Study of the Science of Team Science (2012-2015)**
  - Team dynamics, management, and effectiveness;
  - Institutional and organizational supports;
  - The context of team science, including relevant science policies; and
  - Implications for education, training, workforce

- Final report, **due Jan 2015**, will **review and synthesize** research across disciplines (e.g., science of teams, organizations, management) on **effective collaboration** in science teams, research centers, and institutes

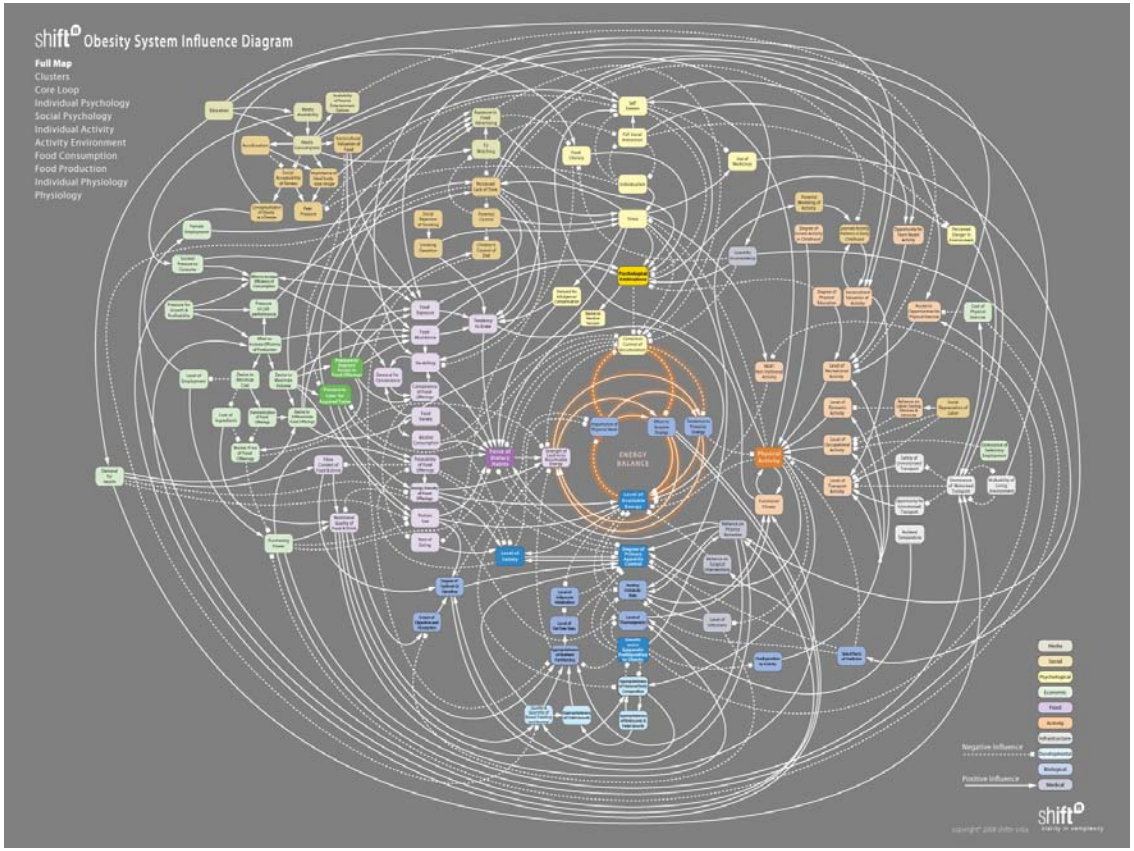
- Committee members represent **diverse disciplines**, including management, communications, IT, psychology, social ecology, medicine

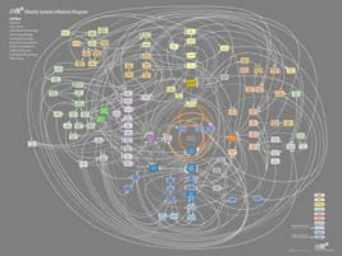
- Conducted by the NAS National Research Council Board on Behavioral, Cognitive, and Sensory Sciences, the Board on Human-Systems Integration and the Board on Science Education

GENERATING SYSTEMS MAP FOR TS

NCI SciTS Team

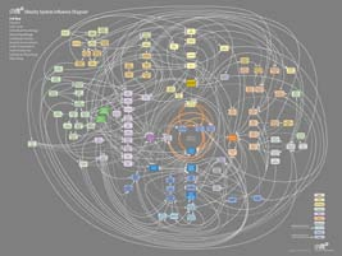
Create a **comprehensive visual representation** of the many factors that influence the success of team-based research, and the pathways by which they exert their independent and interacting influences





GOALS FOR TS SYSTEMS MAP

- Provide a more **holistic understanding of the system** of factors involved in the team science context, processes and outcomes, including possible **leverage points for interventions to maximize effectiveness**
- Depict the current knowledge base in the SciTS field, and help **guide a research agenda** by illuminating –
  - Knowledge base for developing conceptual models and theories
  - Gaps in our current evidence base
- Use as interactive tool to **navigate** (link to) related publications, measures, and practical tools for TS found on the Team Science **Toolkit**



PROCESS FOR DEVELOPING SYSTEMS MAP

Completed:

- **Engaged SciTS 2014 participants** to brainstorm initial ideas

Current:

- **Conducting systematic literature review** to identify factors and their relationships.

Planned:

- **Present initial map at SciTS 2015** and obtain feedback**;** implement a **process for** additional **open public comment** from those not attending the conference will be considered to enhance map
- Engage **TS experts** from a range of stakeholder groups in **a participatory group process** to refine the draft map and recommend related tools, measures to be linked to the map on the Toolkit
- Final map will be **uploaded on the Team Science Toolkit**

NIH National Institutes of Health
Turning Discovery Into Health

SciTS 2015

Building the knowledge base for effective team science

SciTS 2015 Conference | June 2-5, 2015 | Bethesda, Maryland

The conference will bring together **thought leaders** in the SciTS field, **researchers** engaged in team-based science, and **institutional leaders**, **policy makers**, and **federal agency representatives** who support collaborative research.

Central themes include **effective practices and policies for enhancing team science** as well as hot topics and emerging trends such as **team diversity**, **big data**, **citizen science**, **open data**, and **research networking**.

To learn more, go to: www.scitsconference.org

FOR MORE INFORMATION

Team Science Toolkit:
www.teamsciencetoolkit.cancer.gov/

History of the NCI SciTS Team with links to team products:
www.teamsciencetoolkit.cancer.gov/Public/ToolkitTeam.aspx

SciTSlist listserv. *Subscribe in one click:*
www.teamsciencetoolkit.cancer.gov/Public/RegisterListserv.aspx

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