Science of Team Science: Enhancing Transdisciplinary Research

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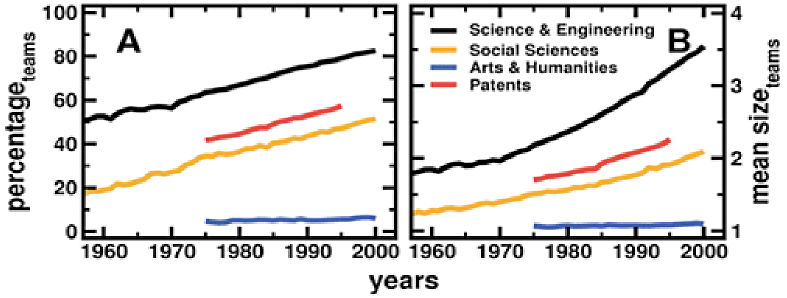
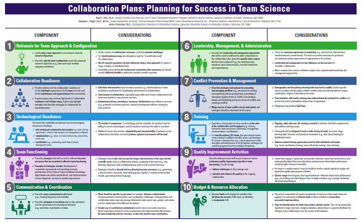
National Cancer Institute

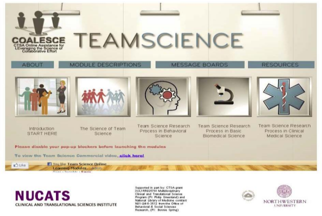
Overview

Introduce the Science of Team Science (SciTS)

Highlight key findings from SciTS and NCI's SciTS Initiative





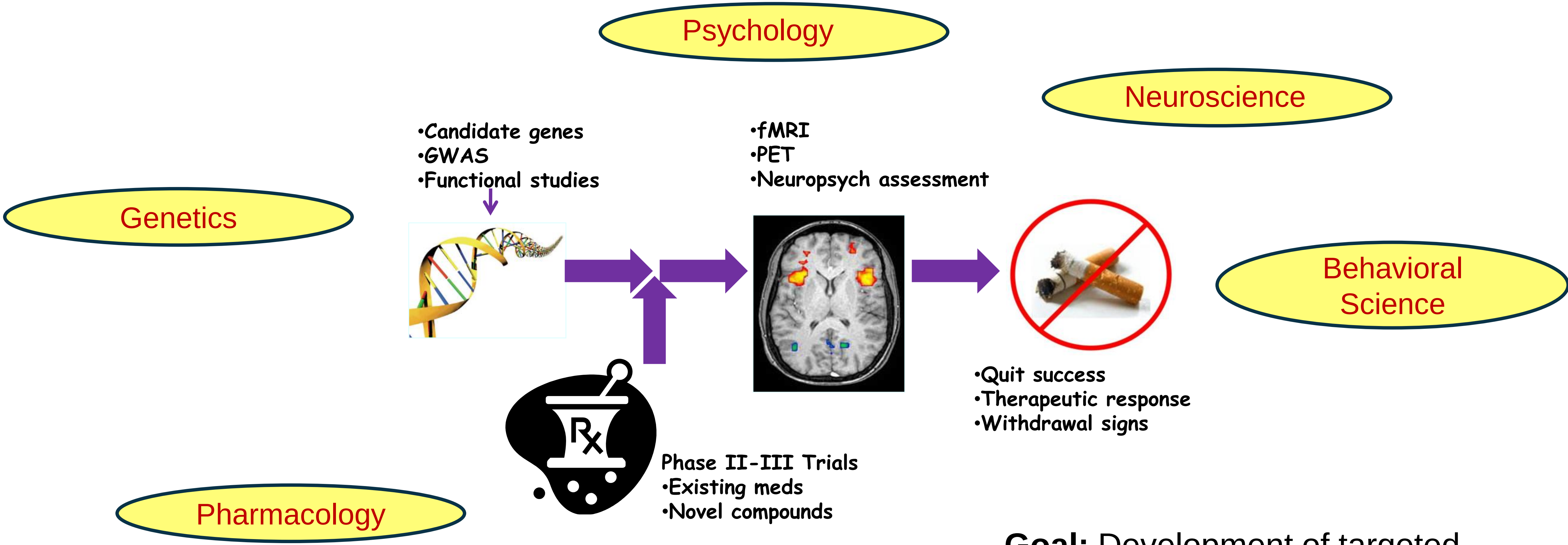


Discuss strategies and lessons learned to facilitate and support team science

Challenge: Silos and Stagnation in Tobacco Research

Advancing Tobacco Research through Transdisciplinary (TD) Integration

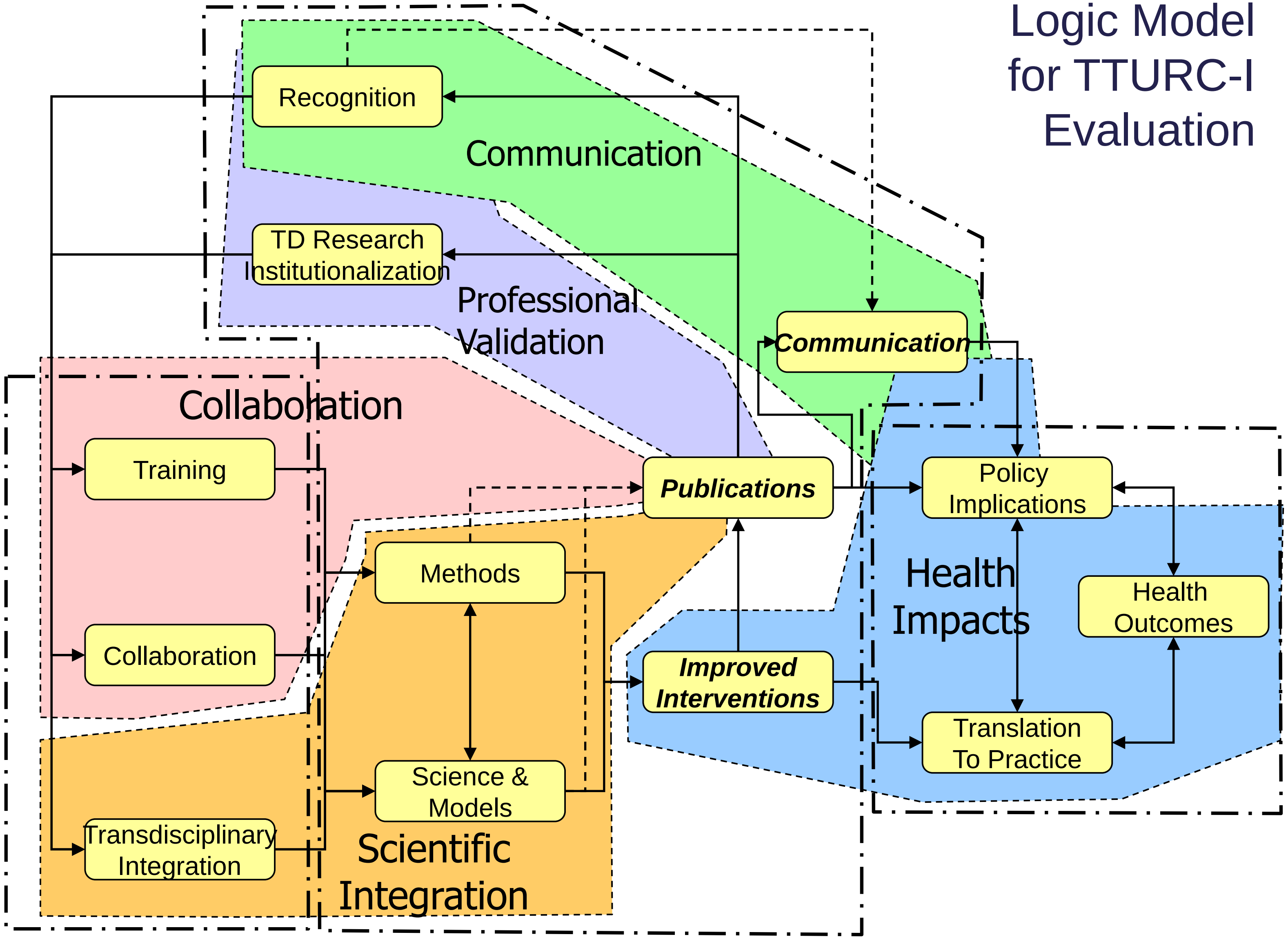
tturc
Transdisciplinary Tobacco Use Research Centers

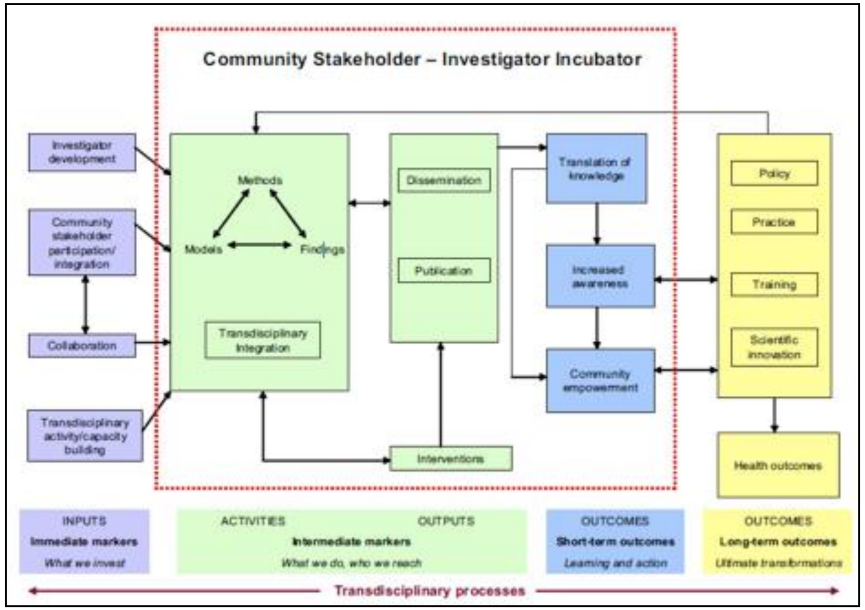


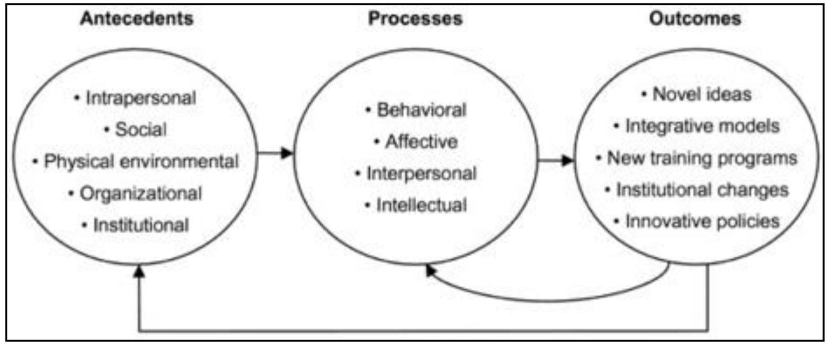
Goal: Development of targeted therapies for nicotine addiction

Adapted from Lerman, 2012

Logic Model for TTURC-I Evaluation





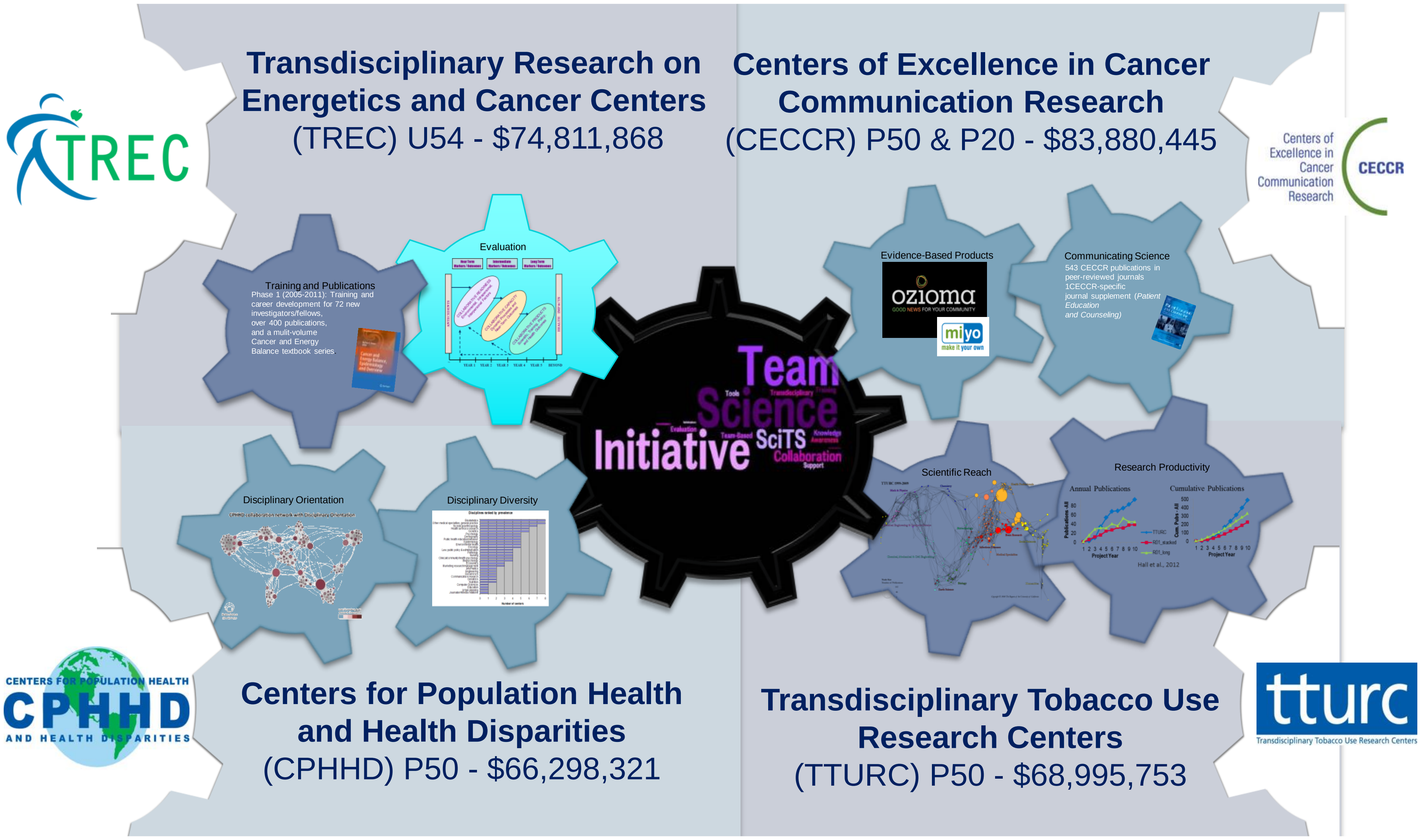


Immediate Markers Intermediate Markers Long-Term Outcomes

Hall, K. L., Stipelman, B. A., Vogel, A. L., & Stokols, D. (2017). Understanding cross-disciplinary team-based research: Concepts and conceptual models from the Science of Team Science. In Frodeman, R., Klein, J. T., & Mitcham, C. (Eds). *Oxford Handbook on Interdisciplinarity, 2nd Edition*. Oxford, UK: Oxford University Press. p338-356.

NCI Transdisciplinary (TD) Center Initiatives

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



SciTS Studies:

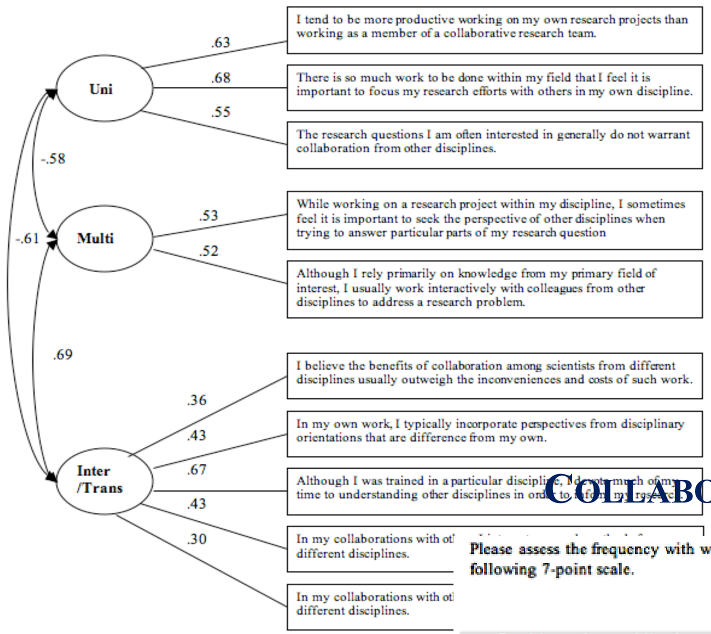
Foci

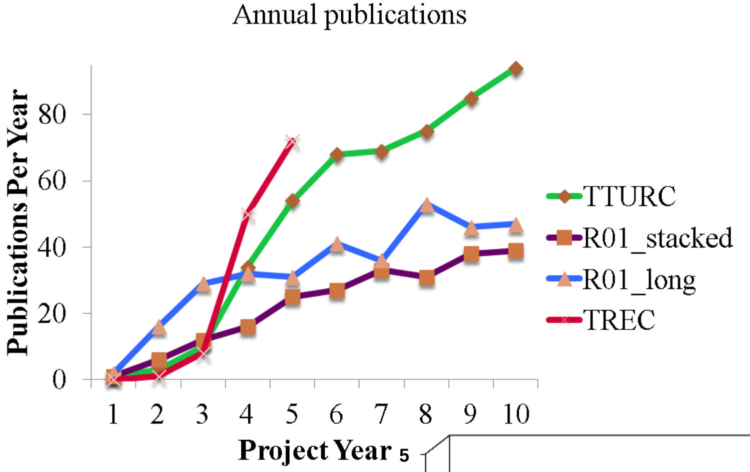
- Integration
- Collaboration
- Productivity
- Impact
- Reach
- Research orientation
- Barriers/Facilitators
- P&T Policies
- Training

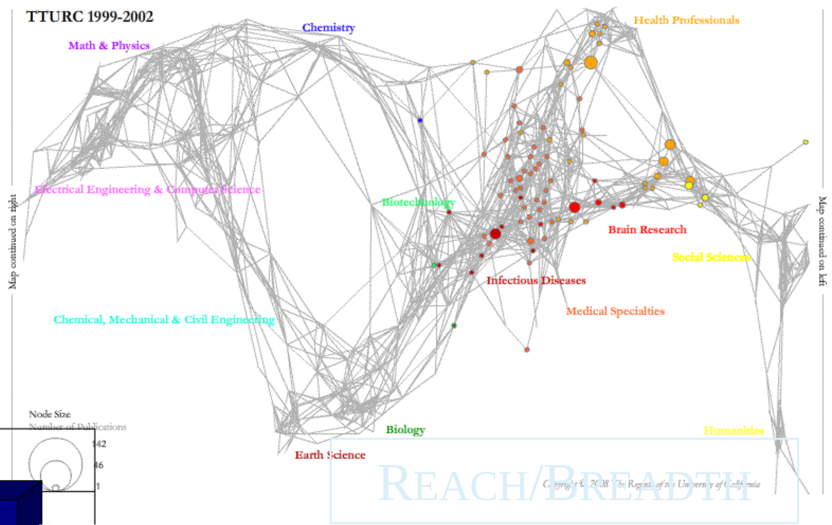
Methods

- Interview
- Survey
- Bibliometric
- Financial
- Science Mapping
- Written Products Protocol
- Social Network Analysis

Research Orientation Scale





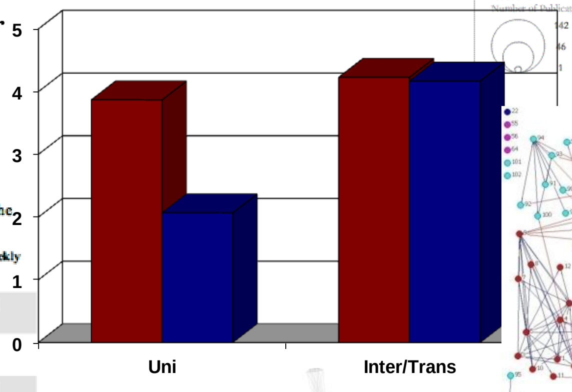


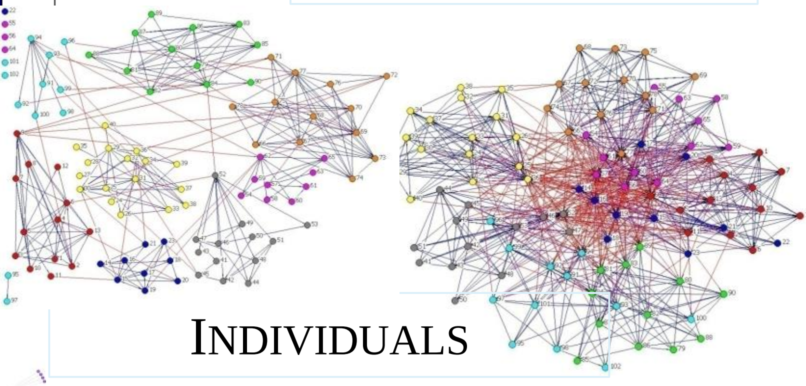
REACH/BREADTH

Collaborative Activities Scale

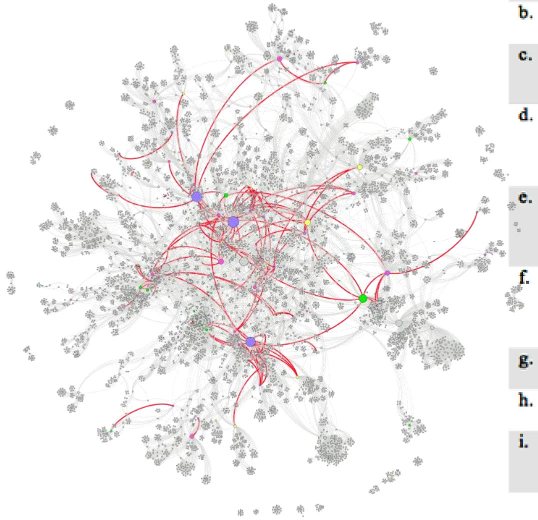
Please assess the frequency with which you typically engage in each of the activities listed below using the following 7-point scale.

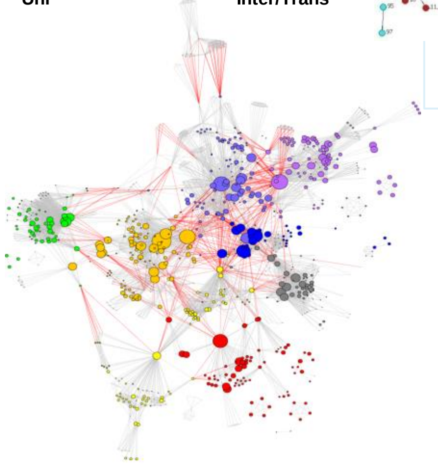
	Never	Rarely	Once a Year	Twice a Year	Quarterly	Monthly	Weekly
a. Read journals or publications outside of your primary field	☐	☐	☐	☐	☐	☐	☐
b. Attend meetings or conferences outside of your primary field	☐	☐	☐	☐	☐	☐	☐
c. Participate in working groups or committees with the intent to integrate ideas with 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	☐	☐	☐	☐	☐	☐	☐



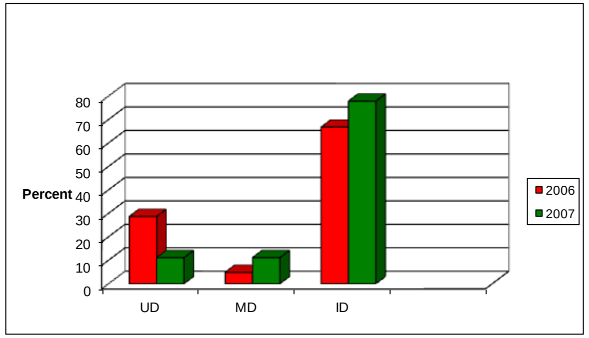


Individuals





1999-2009



Levels of Analysis

Projects and Centers

e.g., Hall et al., 2008; Stipelman, Hall, et al., 2014; Hall et al., 2012

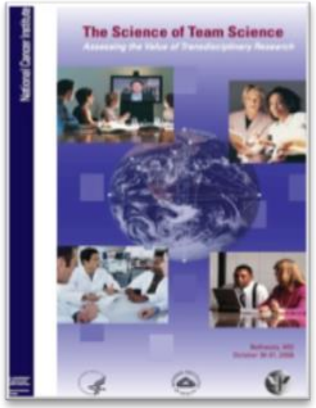
The Science of Team Science is a cross-disciplinary field of study that aims to: **(1) *generate an evidence-base;* and (2) *develop translational applications* to help maximize the efficiency, effectiveness of team science.**

SciTS | Building the knowledge base for effective team science

- **What is the added value of team science?** Can it ask and answer new questions, produce more comprehensive knowledge, generate more effective applied solutions?
- **What team processes (e.g., communication, coordination approaches)** help maximize scientific innovation and productivity?
- What **characteristics and skills of team leaders and team members** facilitate successful team functioning?
- How can **funding agencies and universities** most effectively facilitate and support team science, in order to advance discovery? **What policies are needed?**

Building the SciTS Field

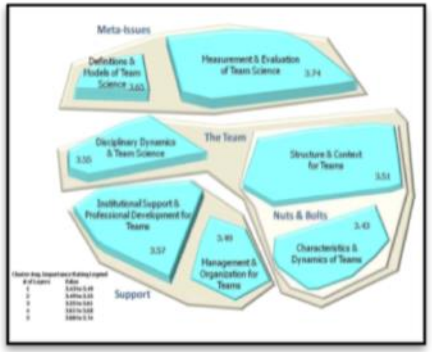
NCI Conference
The Science of Team Science
Assessing the Value of Transdisciplinary Research



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


UCF
Department of Communication
FINAL REPORT
NSF Workshop
Applying the Science of Teams to Inform Policy and Research on Team Science
Stephen M. Fiore
University of Central Florida
Joann Keyton
North Carolina State University

Mapping a Research Agenda for SciTS



Annual SciTS Conference

SciTS | Building the knowledge base for effective team science

INSciTS
New scientific society launched

Forthcoming!

Handbook: **Strategies for Team Science Success:**
Hall et al

2006 → 2008 → 2010 → 2011 → 2012 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018 - - - - →

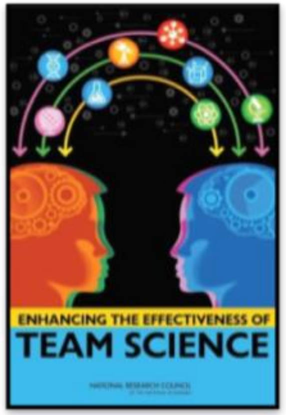
SciTS Journal Supplement


AMERICAN JOURNAL OF PREVENTIVE MEDICINE
The Science of Team Science
Assessing the Value of Transdisciplinary Research
Daniel Stokols, Kara L. Hall, Brandie K. Taylor, Richard P. Moser, and S. Leonard Syme
ACPM
APTR
ELSEVIER

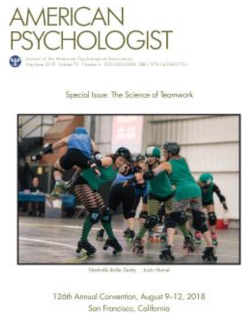
Team Approaches to Science, Practice, & Policy in Health

Collaboration Science & Translational Medicine

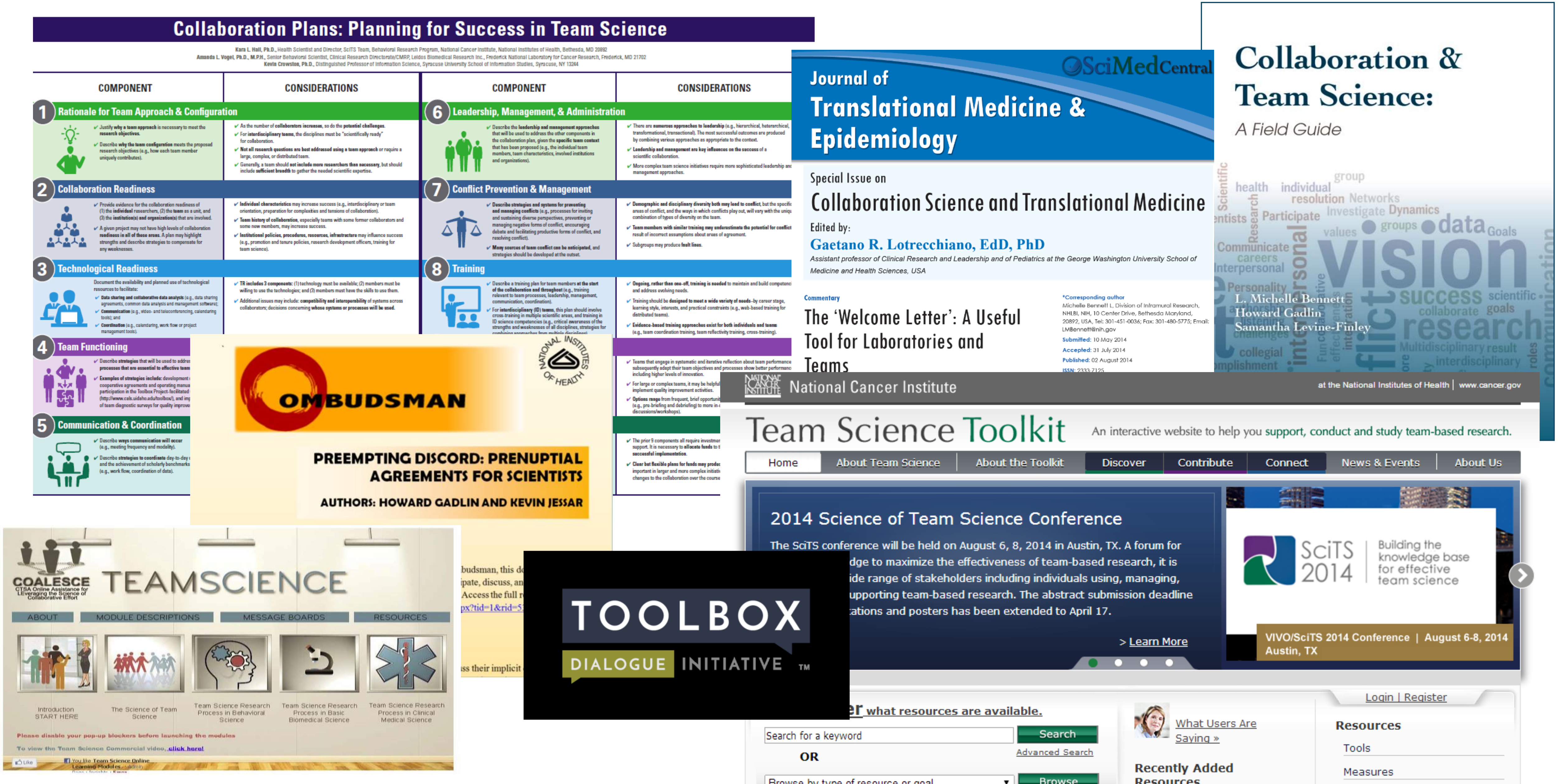
National Academies Consensus Study



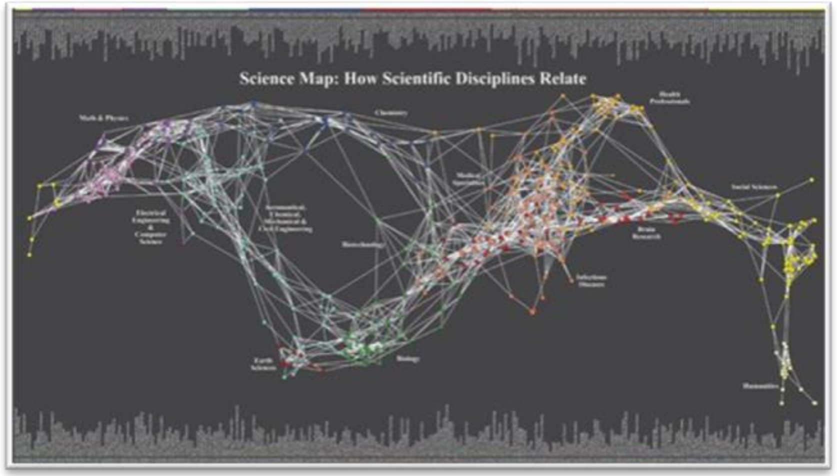
The Science of Team Science: A Review of the Empirical Evidence and Research Gaps on Collaboration in Science

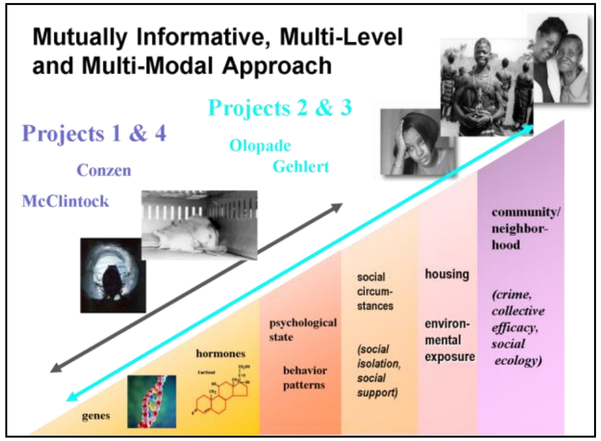


Developing Translational Applications



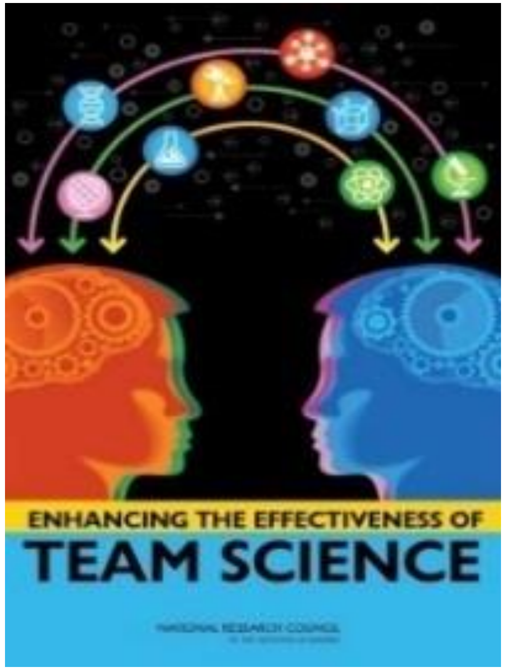
Variations in Team Science





Dimensions of Team Science

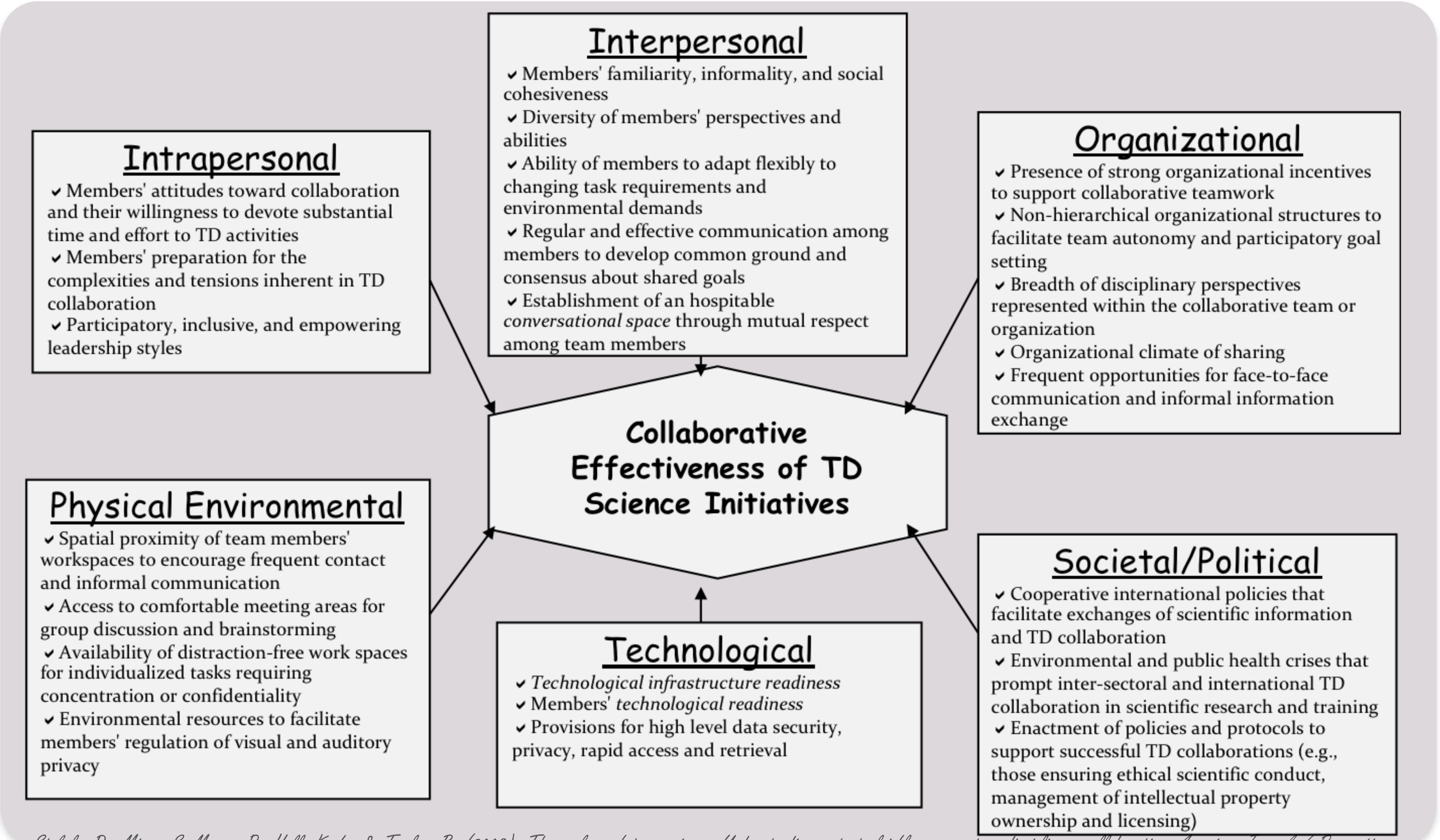
That Create Unique Profiles & Challenges



Dimension	Range	
Diversity	HOMOGENEOUS	HETEROGENEOUS
Integration	UNIDISCIPLINARY	TRANSDISCIPLINARY
Size	SMALL (2)	MEGA (1000S)
Proximity	CO-LOCATED	GLOBALLY DISTRIBUTED
Goal alignment	ALIGNED	DIVERGENT OR MISALIGNED
Boundaries	STABLE	FLUID
Task interdependence	LOW	HIGH

Collaboration Is Complex

Multi-level Contextual Factors



Stokols, D., Misra, S. Moser, R., Hall, K. L., & Taylor, B. (2008). The ecology of team science: Understanding contextual influences on transdisciplinary collaboration. American Journal of Preventive Medicine, 35, 2, S96-S115.

Team Science, Science of Team Science & Science of Teams

What is team science?

- The **approach of conducting research in teams** within complex social, organizational, political, and technological milieu (e.g., the scientific enterprise) that heavily influence how that work occurs

- Involves **more than one individual** working together in an **interdependent** fashion and may include **small scientific teams or larger groups**

- Collaborators from a range of perspectives - **scientific, industry, and community stakeholders**

Are science teams different?

Unique contextual conditions

- Legacy structures of academia
- Sources of support
- Rewards and incentives
- Success metrics
- Motivations for collaboration
- Collaborators who are also competitors

Boundary Spanning Collaborations

Greater Scientific Impact

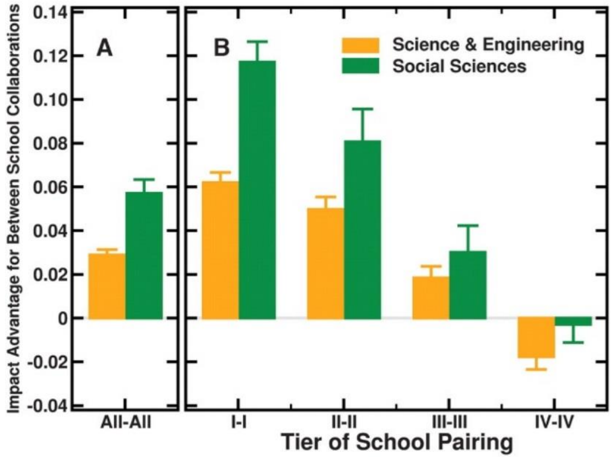
- ***Countries:*** International teams and teams from more locations generally yield **higher impact publications**
  - with certain countries (e.g., US) and universities (R1) increasing the likelihood of positive impacts

- ***Universities:*** Publications with authorship teams spanning different universities produced **higher impact work than comparable co-located teams or solo scientists**

- ***Departments:*** One study found that although the number of departments had a negative effect on a specific type of innovation impact (patents), prior experience among team members reverses this effect

What have we learned from SciTS?

Generally, collaborations spanning organizational and contextual boundaries enhance the impact of the research.



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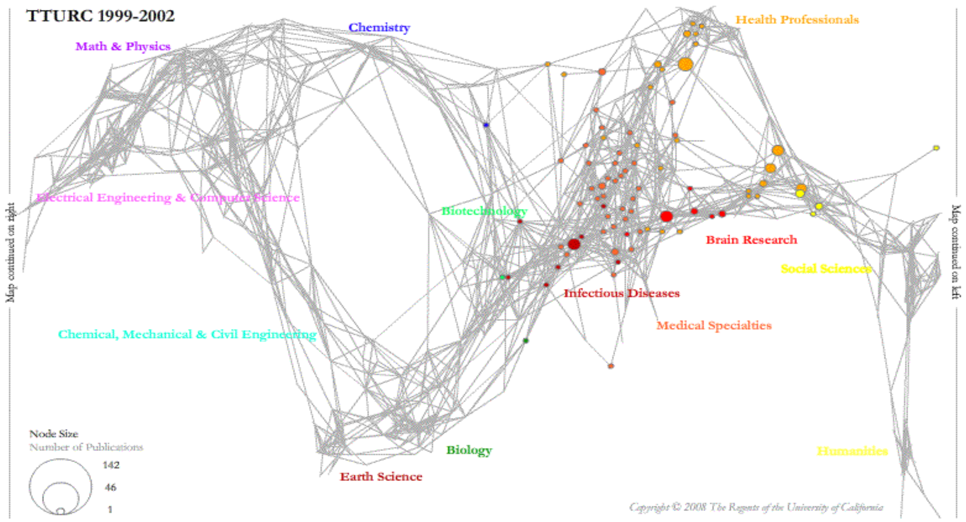
Disciplinary Diversity
Cross-disciplinary teams:

- Found to be **more productive** than comparison teams, as indicated by publications
- Produce **more innovative** products than unidisciplinary teams
- Tend to generate publications with **greater scientific impact**
- **Greater cross-fertilization** via publications with broader reach and decreased specialization
- Identify **new previously unexplored areas** at the intersection of fields/domains

What have we learned from SciTS?

CD are found to be more productive, innovative, yield greater scientific impact, and result in broader dissemination of results.



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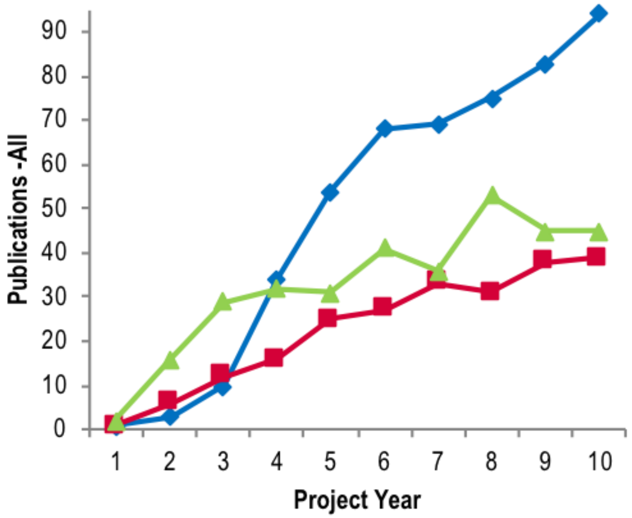
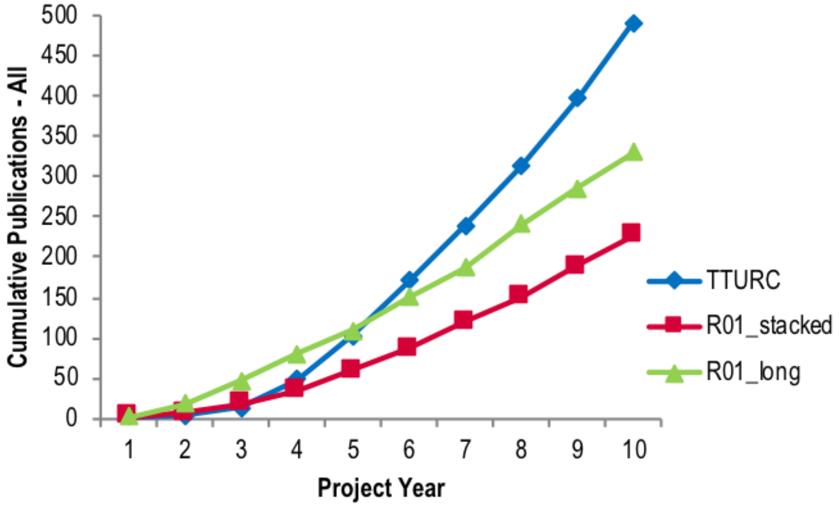
Productivity of TD Center Grants and R01 Investigator-Initiated Grants

Annual Publications



TD center publications have longer start up period compared to R01s but become more productive over time

Cumulative Publications



Centers initial **lag** in number of publications is **eliminated around Project Year 4.**

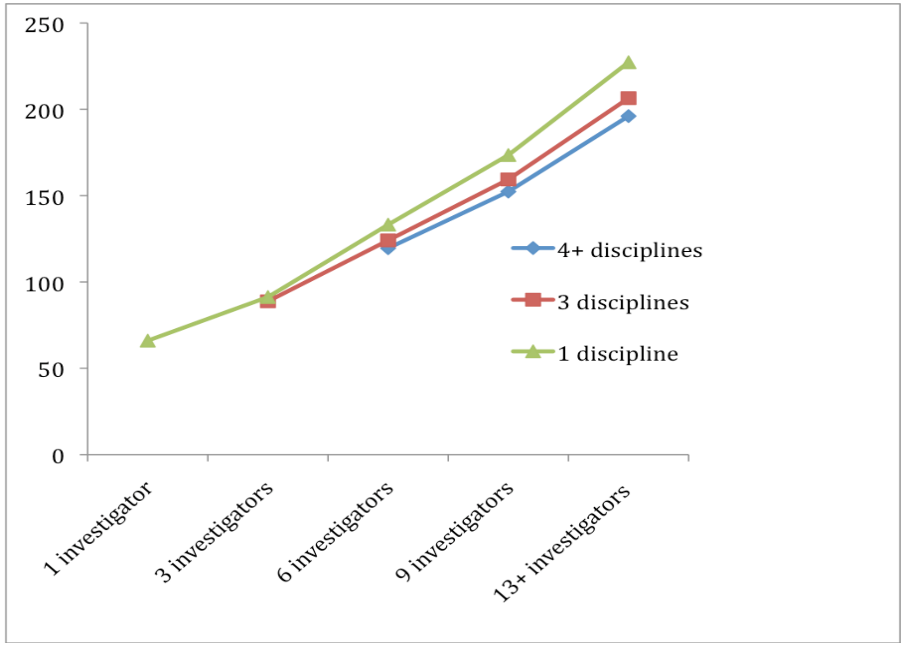
Method: Quasi-experimental design comparing number of publications of TTURC initiative with matched R01 projects from the tobacco field over 10-year period

Hall, K.L., Stokols, D., Stipelman, B.A., Vogel, A.L., Feng, A., et al (2012). Assessing tyhe Value of Team Science: A Study Comparing Center- and Investigator-Initiated Grants. *American Journal of Preventive Medicine 42*, 157-163.

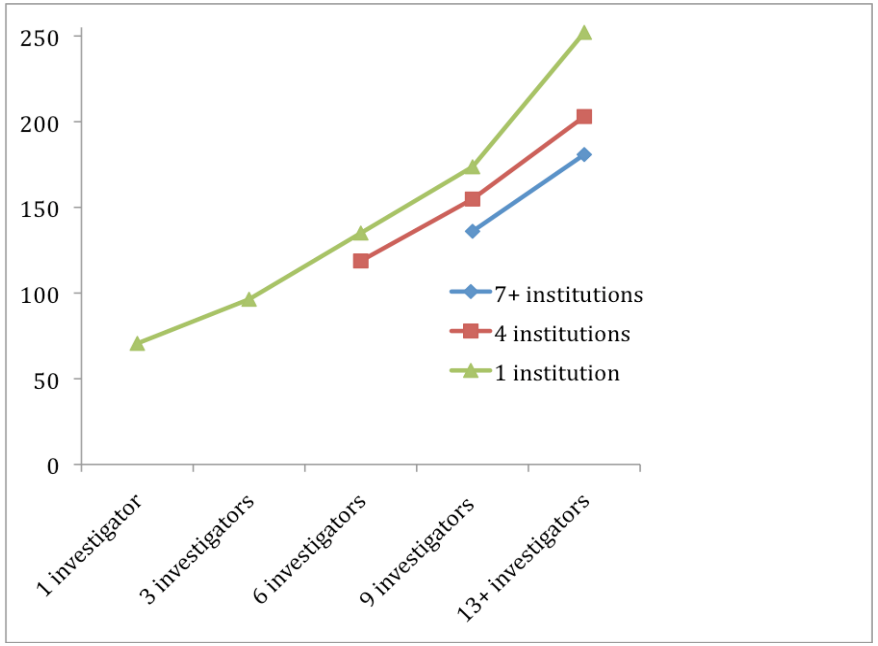
Multi-disciplinary & Multi-Institutional

Team Science Productivity

Predicted number of publications as a function of research group size and heterogeneity as measured by number of disciplines of the investigators



Predicted number of publications as a function of research group size and group heterogeneity as measured by number of institutions involved in the research



Key Findings: **On average, as the number of investigators increase, greater numbers of disciplines and institutions, results in less productivity (important caveat!)**

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.

Coordination, Coordination, Coordination

Enhances success

The projects that used **more coordination mechanisms** had **more successful outcomes,** e.g.,

- Division of responsibility, knowledge transfer, direct supervision, face-to-face mechanisms

The **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

Increases in complexity (e.g., communication, team dynamics, organizational and global bureaucratization) occur **as the number of team dimensions** (e.g., size, disciplines, distribution) **increase.**

- ***Thereby, complex teams require more resources for coordination and management***

What have we learned from SciTS?

- The use of coordination mechanisms is critical for success.
- The number of coordination mechanisms should increase as the complexity of the project increases.

Practical considerations:

- Coordination that **addresses team principles** as related to **team profiles**
- Leaders, managers, facilitators attuned to these principles and require ***specialized skills and strategies***

Hall, K. L., Vogel, A. L., Huang, G. C., Serrano, K. J., Rice, E. L., Tsakraklides, S. P., & Fiore, S. M. (2018). The science of team science: A review of the empirical evidence and research gaps on collaboration in science. *American Psychologist*, 73(4), 532-548.

Gender , Cultural, & Ethnic Diversity

Enhances Outcomes

Gender diversity

- **Gender-Heterogeneous** authorship teams receive **34% more citations** than same-gender
- Scientific **teams with at least one female PI are more likely to win grant proposal** or produce more **innovative ideas.**

Cultural/Ethnic diversity

- Across several studies - **moderate levels of diversity appear to be better than no diversity or very high levels diversity.**

Practical Considerations:

- Diversity adds value
- High levels of diversity increases complexity
- Understand and consider faultlines

Bozeman, et al. 2016; Zeng et.al., 2016, Abramo, D'Angelo, & Murgia; Uhly, Visser, & Zippel, 2015, Abramo et al., 2011, van Rijnsoever & Hessels, 2011; Abramo et al., 2013, Pezzoni et al., 2016, Benenson et al., 2014, Kegel, 2013; Dahlander & McFarland 2015; Abramo et al., 2013, Joshi, 2014, Stvilia et al., 2011, Campbell et al., 2013, Lungeanu et al., 2014; Gibbs et al., in press; **Lungeanu & Contractor 2014**

Team Size & Composition

Scientific progress and breakthroughs

- ***Team size:*** "**small teams** are more likely to produce articles, patents and software that **disrupt the system** by drawing inspiration from older and less popular ideas, while **larger teams build on, solve and refine important ideas** from the immediate past."
- ***Networks:*** Nobel prize winning **breakthroughs** often come from **papers that are not highly cited** and emerge from a **small network** of researchers
- ***History of collaboration:*** Enhances impact and productivity, yet decreases breakthrough products
- ***Newcomers:*** A **combination of members** with a history of collaboration and new team members increase the likelihood of publishing in the most prominent journals

What have we learned from SciTS?

Team size and characteristics can influence the type of outcomes produced.

Practical Considerations:

- What is the ideal team size? 6-9?
- Depends on scope and complexity of problem
- Coordination:
  - Structure
  - Process
  - Resources

Hall, K. L., Vogel, A. L., Huang, G. C., Serrano, K. J., Rice, E. L., Tsakraklides, S. P., & Fiore, S. M. (2018). The science of team science: A review of the empirical evidence and research gaps on collaboration in science. *American Psychologist*, 73(4), 532-548.

The Role of Roles

Differential Influence on Team Effectiveness

- Post-docs with external funding, graduate students, and technicians
  - Increase the likelihood of breakthrough publications
- Postdocs
  - Higher productivity
- Senior co-authors/Higher rank
  - Publication in higher-impact journals than articles co-authored by junior researchers
  - Positive effect on both collaboration and productivity
- Brokers
  - Help to keep a network of researchers interacting
  - Increase scientific output
  - Higher production of scientific discoveries

Summary Points:

The inclusion of different types of roles on team can impact team effectiveness, leading to different kinds of outcomes.

Practical Considerations:

- Why do we see these differences?
- How can we better align team configuration with goals?
- What about stakeholder involvement?

Hall, K. L., Vogel, A. L., Huang, G. C., Serrano, K. J., Rice, E. L., Tsakraklides, S. P., & Fiore, S. M. (2018).
The science of team science: A review of the empirical evidence and research gaps on collaboration in science. *American Psychologist*, 73(4), 532-548.

TREC Structure

116+ investigators
30 disciplines
5 sites

2011-2016

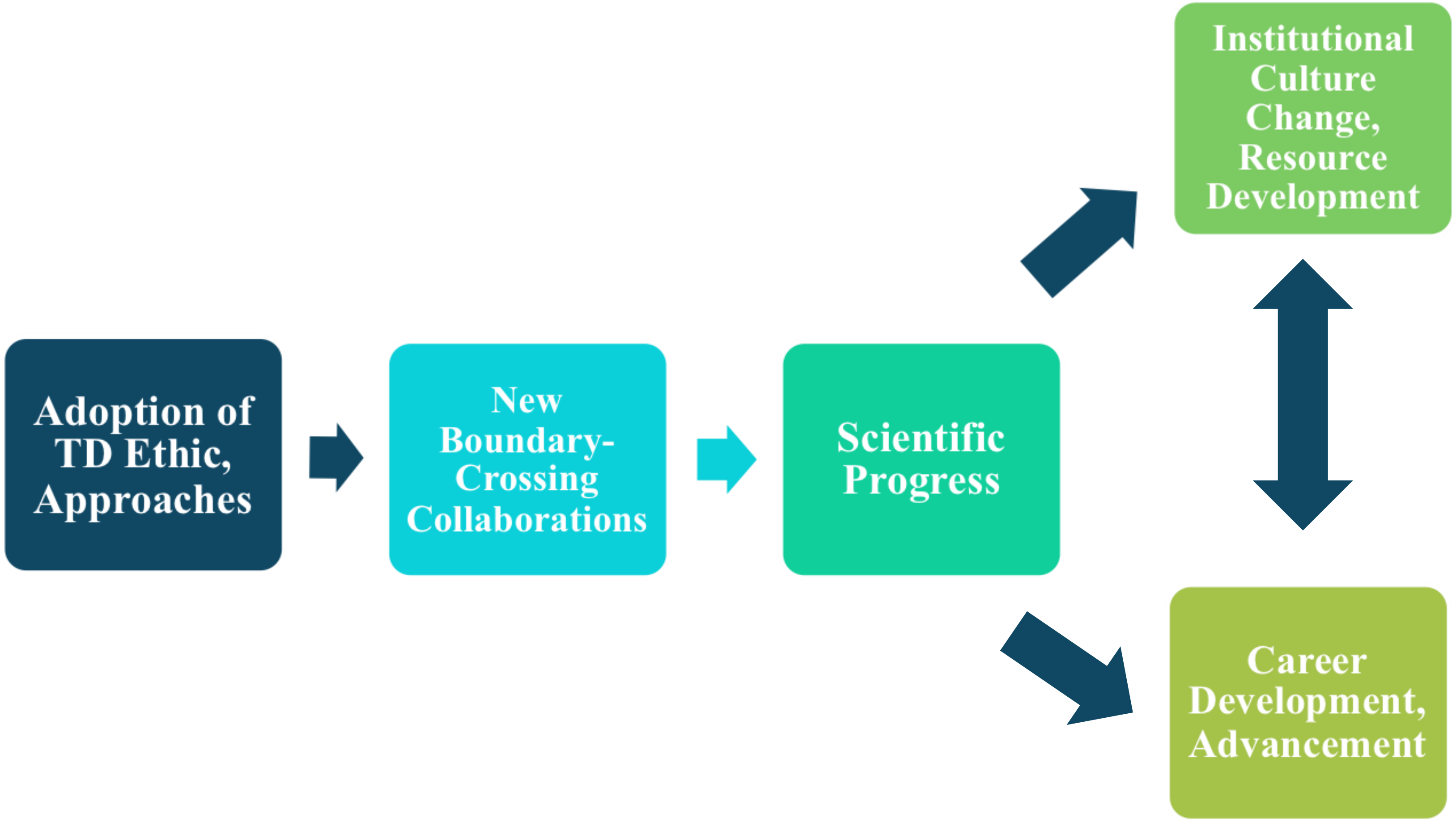
Biochemistry
Genetics
Statistics
Medicine
Social Work
Psychology
Epidemiology
Physical Therapy
Occupational Therapy
Molecular Biology
Systems Science
Urban Planning
Anthropology
Economics
Nutrition
Sociology
Metabolism
Etc.

Challenges in TD Team Science

- **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, A. L., Stipelman, B. A., Hall, K. L., Stokols, D., Nebeling, L., & Spruijt-Metz, D. (2014). Pioneering the transdisciplinary team science approach: Lessons learned from National Cancer Institute grantees. *The Journal of Translational Medicine and Epidemiology, 2*(2): 1027, p1-13.

Impact of Participating in a TD Research Initiative



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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)

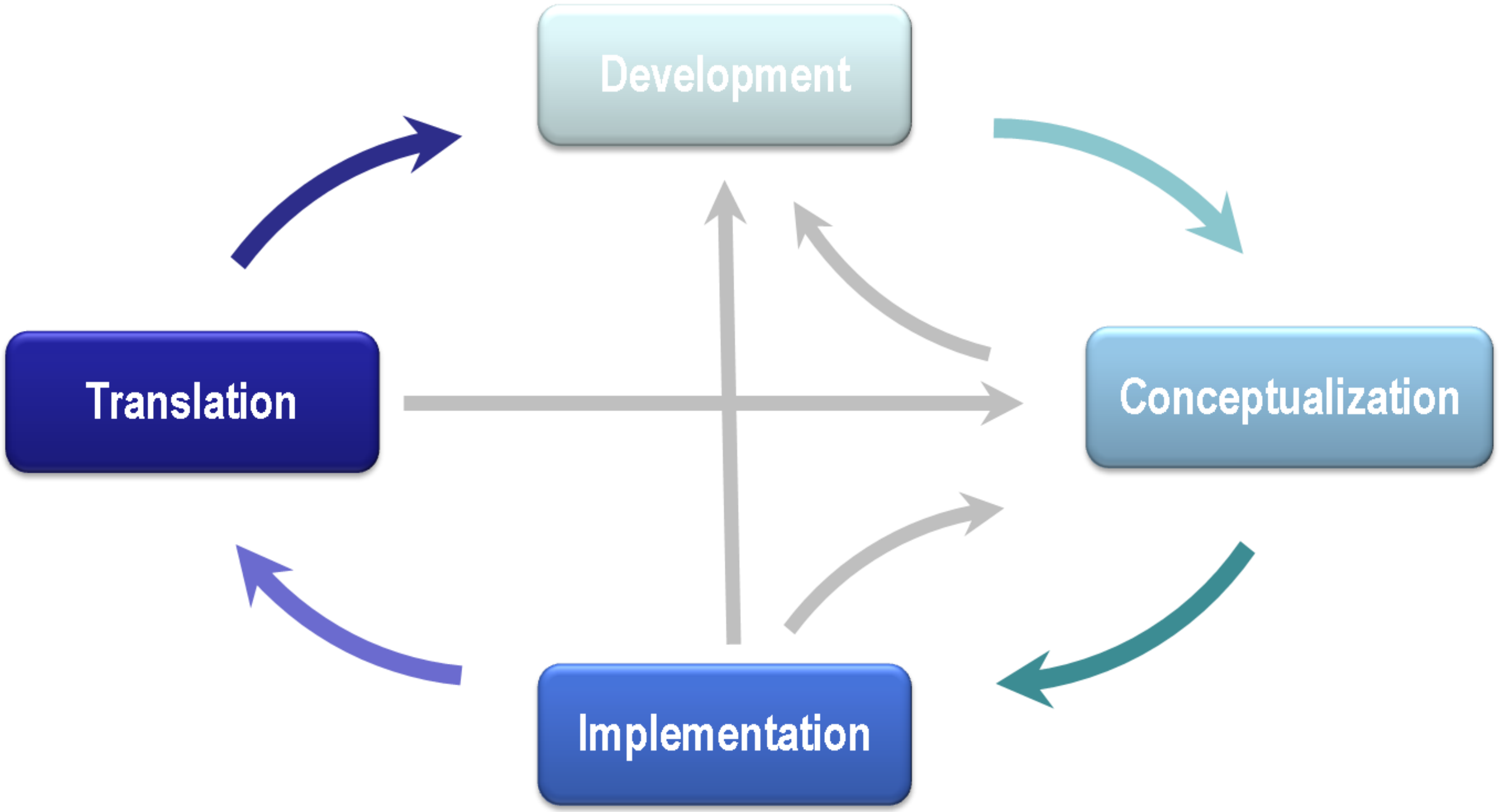
Findings help to illustrate:

- Added value of TD research
- 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

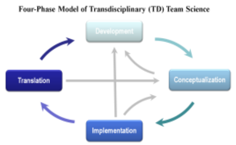
Build on emerging evidence and lessons learned to most effectively and efficiently advance our science

- 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 of Transdisciplinary Research



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, 415-430.*



Development Phase

Goals & Key Processes

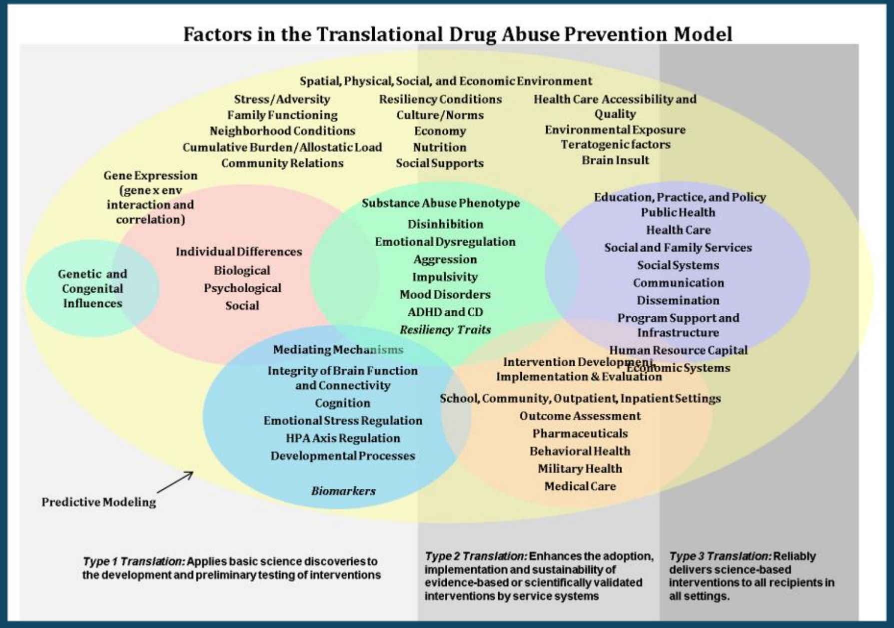
Goal: Define the scientific or societal **problem space** of interest, including identifying the intricacies & interconnections of concepts that fall within the problem space & establishing the boundaries of the problem space to be addressed

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

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

Team Type:

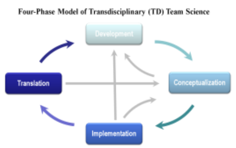
- Network, working group, advisory group, emerging team



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 & the wide variety of relevant disciplines & 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, 415-430.*



Conceptualization Phase

Goals & Key Processes

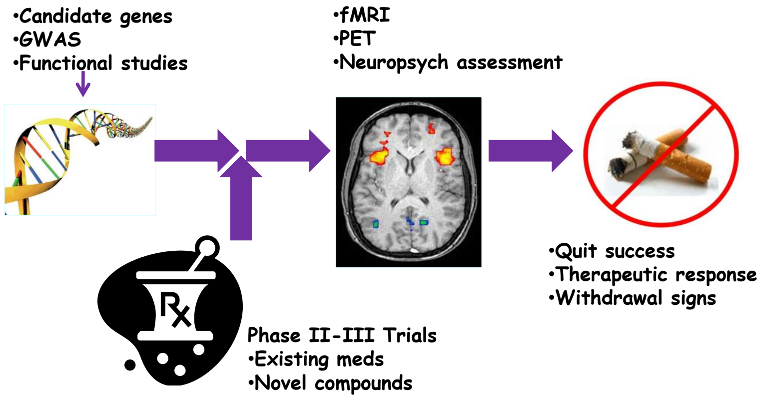
Goal: Develop novel research questions, hypotheses, & a conceptual framework & research design that integrate collaborators' disciplinary perspectives & knowledge domains to address the target problem in innovative ways.

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

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

Team Type:

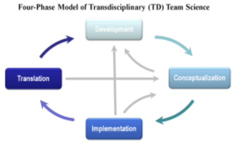
- Emerging team, evolving team



Lerman, 2012

Use public seminars among collaborators to help develop compilational transactive memory, shared language for a TD research collaboration, team TD ethic, & 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, 415-430.*



Implementation Phase

Goals & Key Processes

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

Key Processes:

Developing a shared understanding (transactive memory)

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

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

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

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

- Conflict Management
- Team Learning (e.g., reflection, action, feedback, discussion)

Team Type:

Real team

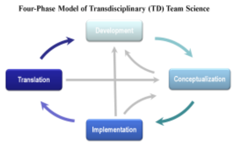
"Real" vs "Pseudo" team

Characteristics that lead to increased performance & innovation:

- **Interdependence**
- **Iterative reflection** (systematic consideration of team performance & participation in related adaptation to team goals & processes)
- Demonstrated clear **understanding of team membership**

Source: 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

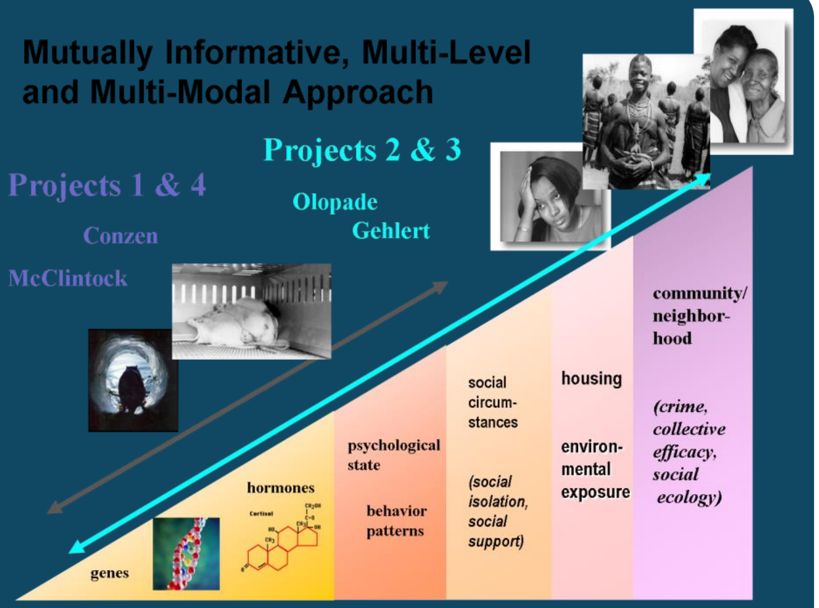
Goals & Key Processes

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 & pursue translational goals
- Development of shared goals for the translational endeavor
- Development of shared understandings of how these goals will be pursued

Team Type:
Adapted team, new team



Initiate community outreach activities to identify translational partners to evolve the TD team. Work together to identify & implement translational goals in ways that draw upon the expertise of both investigators & translational partners

Source: 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).

Culture Shift – Reward & Recognize

Disciplinary-oriented Independent Scientist	Transdisciplinary Team Scientist
Independence	Interdependent

- “Candidates for tenure and promotion are **encouraged to pursue innovation wherever it seems promising, *even* at the edges of disciplinary boundaries or in between them**.” (Indiana U CA 2016)
- ”…The chair/dean must solicit **letters from collaborators** and co-authors, ***attesting to the autonomous* contributions** of the candidate.” (Indiana U CA 2016)
- “**National reputation** as an **original, independent investigator** and major contributor to the field; may include senior author on high quality publications that have advanced the field, ***perhaps with additional publications from collaborative research*** that significantly advance biomedical science to which the candidate contributed critical ideas or innovations” (Cornell U MS 2016)

Workforce Preparation - TD Team Science Competencies

Intrapersonal

- Demonstrate **broad intellectual curiosity** to ask questions across disciplines
- Maintain an **open mind** to clearly hear perspectives of others during explorative ID dialogues
- Recognize **personal strengths and weaknesses** within ID research collaboration
- **Subject own disciplinary discovery to interpretation** and scrutiny by researchers from other disciplines
- Understand **how own expertise can contribute** to addressing a problem and how that differs from the contributions of others

Disciplinary Awareness & Exchange

- Demonstrate **critical awareness** of the underlying assumptions of own discipline, its scope and contribution and limitations in addressing a given research question
- **Evaluate the assumptions and limitations of all disciplines** in ID collaborative initiatives
- **Engage colleagues** from other disciplines to gain their perspectives on research problems, themes or topics
- **Share research** from own area of expertise in **language meaningful** to people outside one's discipline
- **Modify research plans or agendas** as a result of interactions with colleagues from fields other than own

Collaboration Plans: Planning for Success in Team Science

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Kevin Crowston, Ph.D., Distinguished Professor of Information Science, Syracuse University School of Information Studies, Syracuse, NY 13244

1 Rationale for Team Approach & Configuration

COMPONENT

- ✔ Justify **why a team approach** is necessary to meet the **research objectives.**
- ✔ Describe **why the team configuration** meets the proposed research objectives (e.g., how each team member uniquely contributes).

CONSIDERATIONS

- ✔ As the number of **collaborators increases**, so do the **potential challenges.**
- ✔ For **interdisciplinary teams**, the disciplines must be "scientifically ready" for collaboration.
- ✔ **Not all research questions are best addressed using a team approach** or require a large, complex, or distributed team.
- ✔ Generally, a team should **not include more researchers than necessary**, but should include **sufficient breadth** to gather the needed scientific expertise.

2 Collaboration Readiness

COMPONENT

- ✔ Provide evidence for the collaboration readiness of (1) the **individual** researchers, (2) the **team** as a unit, and (3) the **institution(s) and organization(s)** that are involved.
- ✔ A given project may not have high levels of collaboration **readiness in all of these areas.** A plan may highlight strengths and describe strategies to compensate for any weaknesses.

CONSIDERATIONS

- ✔ **Individual characteristics** may increase success (e.g., interdisciplinary or team orientation, preparation for complexities and tensions of collaboration).
- ✔ **Team history of collaboration**, especially teams with some former collaborators and some new members, may increase success.
- ✔ **Institutional policies, procedures, resources, infrastructure** may influence success (e.g., promotion and tenure policies, research development officers, training for team science).

3 Technological Readiness

COMPONENT

Document the availability and planned use of technological resources to facilitate:

- ✔ **Data sharing and collaborative data analysis** (e.g., data sharing agreements, common data analysis and management software);
- ✔ **Communication** (e.g., video- and teleconferencing, calendaring tools); and
- ✔ **Coordination** (e.g., calendaring, work flow or project management tools).

CONSIDERATIONS

- ✔ **TR includes 3 components:** (1) technology must be available; (2) members must be willing to use the technologies; and (3) members must have the skills to use them.
- ✔ Additional issues may include: **competibility and interoperability** of systems across collaborators; decisions concerning **whose systems or processes will be used.**

4 Team Functioning

COMPONENT

- ✔ Describe **strategies** that will be used to address **key team processes that are essential to effective team functioning.**
- ✔ **Examples of strategies include:** development of cooperative agreements and operating manuals, participation in the Toolbox Project-facilitated workshops (http://www.cals.uidaho.edu/toolbox/), and implementation of team diagnostic surveys for quality improvement.

CONSIDERATIONS

- ✔ Strategies should **take into account the unique characteristics of the team and the scientific work**, such as collaborative history, complexity of the team (e.g., size, diversity, dispersion, task interdependence), phase of the research process.
- ✔ Strategies should be **directly tied to achieving key team processes** (e.g., generating a shared mission and goals, externalizing group cognition, creating shared mental models, generating shared language).

5 Communication & Coordination

COMPONENT

- ✔ Describe **ways communication will occur** (e.g., meeting frequency and modality).
- ✔ Describe **strategies to coordinate** day-to-day operations and the achievement of scholarly benchmarks (e.g., work flow, coordination of data).

CONSIDERATIONS

- ✔ **Plans should be specific to your team.** For example, **distance collaborations** increase potential communication and coordination challenges. Communication and coordination styles may vary among collaborators who vary in age, gender, and culture, and for collaborators from different disciplines.
- ✔ **Greater use of coordination mechanisms** leads to more successful outcomes. Direct supervision and face-to-face mechanisms have demonstrated effectiveness. **As team complexity and size increase, so does the need for more coordination.**

6 Leadership, Management, & Administration

COMPONENT

- ✔ Describe the **leadership and management approaches** that will be used to address the other components in the collaboration plan, given the **specific team context** that has been proposed (e.g., the individual team members, team characteristics, involved institutions and organizations).

CONSIDERATIONS

- ✔ There are **numerous approaches to leadership** (e.g., hierarchical, heterarchical, transformational, transactional). The most successful outcomes are produced by combining various approaches as appropriate to the context.
- ✔ **Leadership and management are key influences on the success** of a scientific collaboration.
- ✔ More complex team science initiatives require more sophisticated leadership and management approaches.

7 Conflict Prevention & Management

COMPONENT

- ✔ **Describe strategies and systems for preventing and managing conflicts** (e.g., processes for inviting and sustaining diverse perspectives, preventing or managing negative forms of conflict, encouraging debate and facilitating productive forms of conflict, and resolving conflict).
- ✔ **Many sources of team conflict can be anticipated**, and strategies should be developed at the outset.

CONSIDERATIONS

- ✔ **Demographic and disciplinary diversity both may lead to conflict**, but the specific areas of conflict, and the ways in which conflicts play out, will vary with the unique combination of types of diversity on the team.
- ✔ **Team members with similar training may underestimate the potential for conflict** as a result of incorrect assumptions about areas of agreement.
- ✔ Subgroups may produce **fault lines.**

8 Training

COMPONENT

- ✔ Describe a training plan for team members **at the start of the collaboration and throughout** (e.g., training relevant to team processes, leadership, management, communication, coordination).
- ✔ For **interdisciplinary (ID) teams**, this plan should involve cross-training in multiple scientific areas, and training in ID science competencies (e.g., critical awareness of the strengths and weaknesses of all disciplines, strategies for combining approaches from multiple disciplines).

CONSIDERATIONS

- ✔ **Ongoing, rather than one-off, training is needed** to maintain and build competencies and address evolving needs.
- ✔ Training should be **designed to meet a wide variety of needs**—by career stage, learning style, interests, and practical constraints (e.g., web-based training for distributed teams).
- ✔ **Evidence-based training approaches exist for both individuals and teams** (e.g., team coordination training, team reflectivity training, cross-training).

9 Quality Improvement Activities

COMPONENT

Describe what processes will be put in place to ensure **continuous quality improvement specific to team functioning**, in order to help:

- ✔ **address challenges** as they emerge; and
- ✔ **maintain and enhance the quality** of the ongoing collaboration.

CONSIDERATIONS

- ✔ Teams that engage in systematic and iterative reflection about team performance and subsequently adapt their team objectives and processes show better performance, including higher levels of innovation.
- ✔ For large or complex teams, it may be helpful to involve outside experts to design and implement quality improvement activities.
- ✔ **Options range** from frequent, brief opportunities for reflection about team performance (e.g., pre-briefing and debriefing) to more in-depth activities (e.g., surveys, facilitated discussions/workshops).

10 Budget & Resource Allocation

COMPONENT

- ✔ Allocate **funds** in the budget for activities that **facilitate the success** of the team, as identified **in components 1–9.**

CONSIDERATIONS

- ✔ The prior 9 components all require investments of resources that require financial support. It is necessary to **allocate funds** to these activities to **ensure their successful implementation.**
- ✔ **Clear but flexible plans for funds may produce optimal results.** This can be particularly important in larger and more complex initiatives, where there is a greater likelihood for changes to the collaboration over the course of the initiative.

https://www.teamsciencetoolkit.cancer.gov/Public/TSResourceBiblio.aspx?tid=3&rid=3261

Kara L. Hall, PhD

hallka@mail.nih.gov

Team Science Toolkit

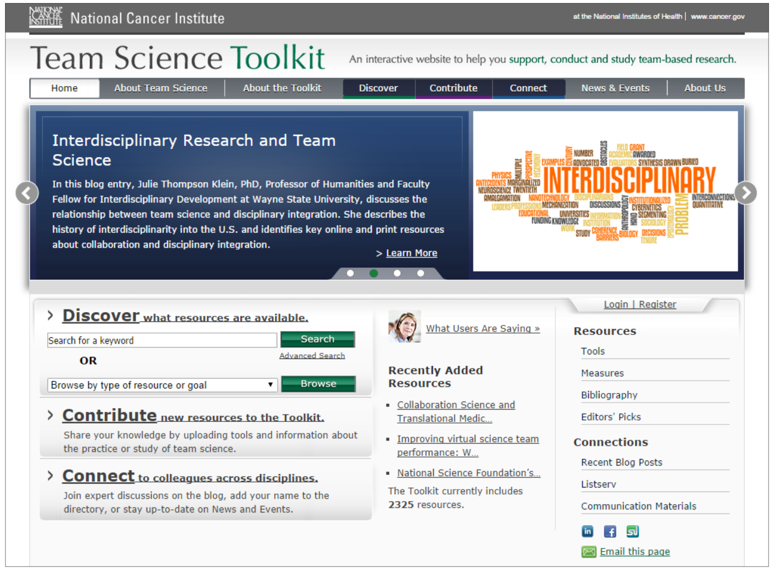
www.teamsciencetoolkit.cancer.gov

Annual SciTS Conference

http://www.scienceofteamscience.org/

SciTSlist listserv hosted by NCI

www.teamsciencetoolkit.cancer.gov/Public/RegisterListserv.aspx



Continuum of Disciplinary Integration

Transdisciplinary

Researchers from *different disciplines* work *jointly* to develop & use a shared conceptual framework that synthesizes & extends discipline-specific theories, concepts, & 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

Adapted from: Rosenfeld, 1992; Hall et al., 2008; Falk-Krezsinski; 2012; Austin et al., 2008; Nissani, 1995

Convergence

Convergence can be characterized as the **deep integration of knowledge, techniques, and expertise from multiple fields to form new and expanded frameworks for addressing scientific and societal challenges and opportunities**. It is related to other concepts used to identify research that spans disciplines: *transdisciplinary, interdisciplinary, and multidisciplinary*. Convergence research is an intentional process. It is **most closely linked to transdisciplinary research** in its merging of distinct and diverse approaches into a unified whole to foster new paradigms or domains. primary characteristics:

Deep integration across disciplines. As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities and languages become increasingly intermingled or integrated. New frameworks, paradigms or disciplines can form from sustained interactions across multiple communities.

Research driven by a specific and compelling problem. Convergence research is generally inspired by the need to address a specific challenge or opportunity, whether it arises from deep scientific questions or pressing societal needs.

Support for Development Phase

What are the challenges?

- Adequate support to break down barriers across disciplines
- Need to rapidly develop complex projects, new teams

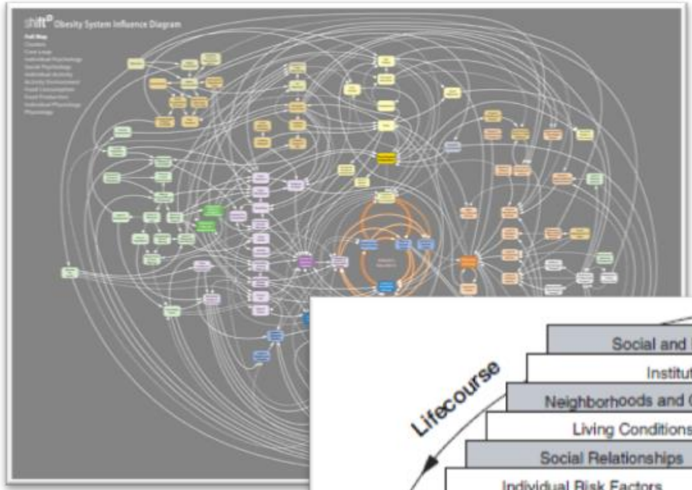
What can be done?

- Enhance readiness of teams
  - Team formation, idea generation
- Forecast scientific areas of need/interest aligned with strategic capabilities
  - Discussions, roundtables, workshops, meetings, special issues, commentaries, blogs

What are some strategies?

- Research networking tools
- Use of seed funds (structured processes, strategic priorities)

The societal & scientific problems are complex –



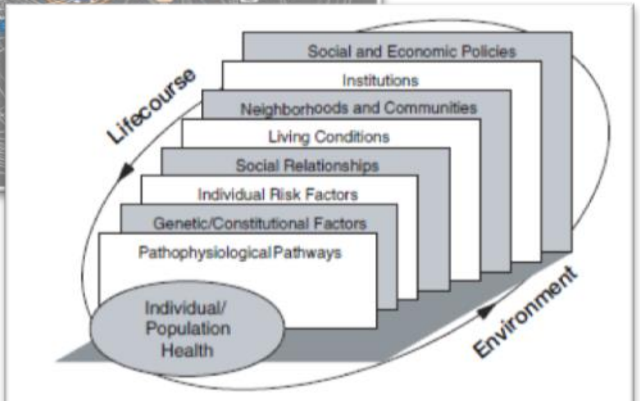


FIGURE A–2 Multilevel approach to epidemiology.
SOURCE: Institute of Medicine (2000).

Multi-level, multi-factorial, interacting influences

Strategies for Stimulating New Collaborations and Innovative Ideas

New Collaborations

- The provision of resources such as **seed funding for pilot projects, or retreats,** have been linked to increases in new collaborations

New Grant Funding

- Medical University of South Carolina's CTSA - South Carolina Clinical & Translational Research (SCTR) Institute - has initiated biannual scientific retreats often with **speed dating style networking sessions.**
  - The average cost per retreat ~$5,000
  - Estimate of extramural grant funding stemming from the five retreats was $20,228,047
  - ROI = **$809 for each dollar spent on the retreats**.

New Ideas – strategic visions, programs of research

- NCI, NSF, DOD, NAS supporting Ideas labs

Sandpits, Ideas Labs, Innovation Labs

2017 NCI-CRUK Sandpit, April 24-26

Knowledge Integration for Cancer Prevention

2018 NCI-CRUK Sandpit, October 29-31

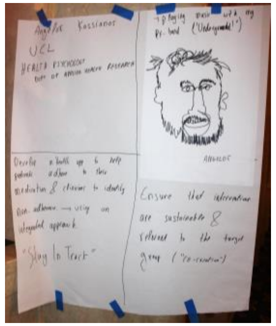
Implementing Digital Health Interventions for Cancer Prevention

Facilitating Novel Projects and Teams

Setting the Stage

Picasso in a Bag

Pair Introductions



Speakers - Speed dating

Idea Generation

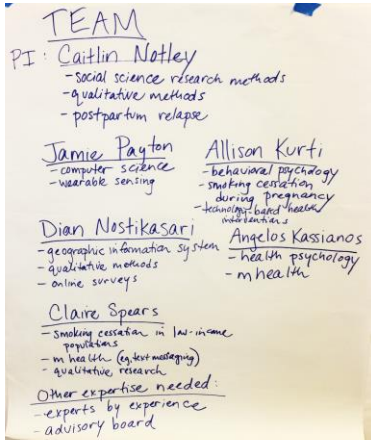
Questions, Clustering, Teaming

Mental Models

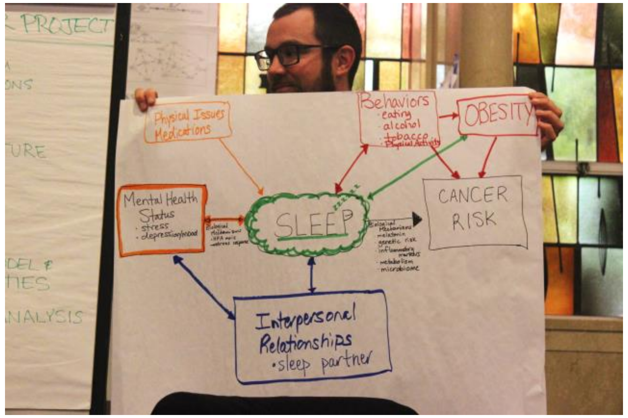
Feedback – Soap boxes

Project Development

Team Formation



Project Pitches

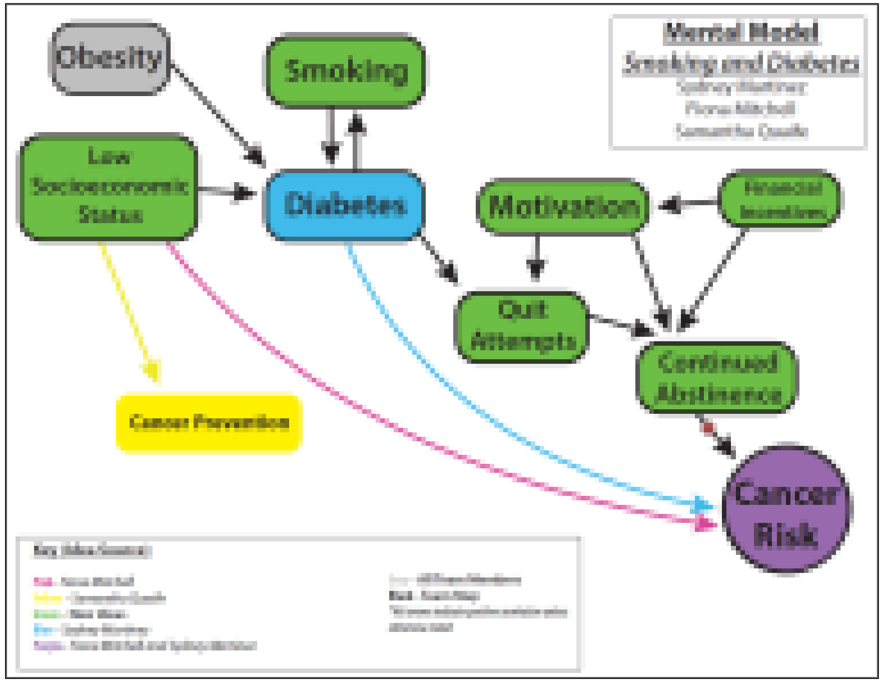


Expert Review - Funding

New Team and New Projects Launched in 3-days

Funded Projects: 5 US/UK Teams

- Smoking abstinence in postpartum women
- Sleep and cancer risk
- Implementation and adoption of pricing interventions
- Contingency strategies for diabetic smokers
- Neuroscience, emotion, and obesity



Influences of Pilot / Seed Funds

Trainees credited TREC with….

- Leading them into **new TD areas of research** – influencing or altering their research interests, confirming their interest in energetics and cancer
- Making them into "**TD researchers**", both by working in the interstices between disciplines, and using TD methodological approaches
- Facilitating **new collaborations** and **innovative TD research** projects they were leading
- Making them more successful in obtaining **grants** that supported career advancement – DPPs, R03s, K awards
- Helping them get experiences that made them **more competitive on the job market** – research topics and methods, team work, writing grant app's and manuscripts

Vogel, A. L., Stipelman, B. A., Hall, K. L., Stokols, D., Nebeling, L., & Spruijt-Metz, D. (2014). Pioneering the transdisciplinary team science approach: Lessons learned from National Cancer Institute grantees. *The Journal of Translational Medicine and Epidemiology* 2(2): 1027, p1-13.

Creating and Maintaining a Vision

Use of Advisory Boards (Internal & External)

- Feedback within and across projects
- Counterbalance regression toward the mean of UD functioning by forcing the bigger picture of an initiative
- Facilitate communication and collaboration among projects
- Instrumental in nudging change regarding university structures, operations, and policies to foster transdisciplinary team science

Critical Nature of Setting Visions:
University, Schools, Departments, Institutes, Centers, Projects

- Who does it?
- How are they trained?
- Are they recognized/rewarded?
- What are the implications?

Examples of Recommendations

Topic	Actions
Resource utilization	Use of female pups from one study and expand vs sacrifice
Translation	Shift of timing of pilot funds to encourage earlier results
Integration of projects/cores	Projects sharing data elements and measures
Change in university culture for TS	Discussions resulting in P&T policies

Adapted from Gehlert et al. in press

Support for Coordination and Management

What is the challenge?

- Inadequate appreciation of how poor coordination mechanisms influences scientific outcomes
  - When project budgets are cut 20-30% the first items eliminated were (Cummings & Keisler, 2005):
    - support for coordination and knowledge transfer activities, such as support of postdoctoral fellows, project managers, seminars, and workshops.
- Inadequate coordination, administration, management infrastructure within institutions
- Need highly skilled coordination/management staff

What are some strategies?

- Approaches to maintain support/coordination of highly skilled coordination/management staff
- Shared/pooled strategies (Cross project, department, institution) for leveraging specialized resources and skills (& consideration of new roles) (e.g., Broad Institute)
- Safety nets / Special projects to maintain and leverage skilled staff

P&T Approaches for Team Science

A Template for Integrating Interdisciplinary Research and Team Science into the Tenure Track Offer Letter

Although every recruitment is unique, emphasis on interdisciplinary and multidisciplinary science is becoming quite common. Research institutions wanting to encourage collaborative research while promo development of bright early career researchers need to establish well-defined guidelines for review and reward of those who engage in interdisciplinary science. It is crucial that offer letters explicitly delineate what is expected of both the institution and the individual scientist The template below identifies a set of questions the answers to which ought to be clear from either the offer letter or ancillary communications with the recruit.

Participating in or Leading and Interdisciplinary Research Project

Roles, Responsibilities, Expectations

1. What will be the role of the individual?
2. What will be expected of the early career scientist?
3. How will success defined for those participating in interdisciplinary research? Leading an interdisciplinary team?
4. What will be the role of the department? Chair?
5. What will be expected of the department? Chair?

Review and Reward*

1. Success: What criteria will be used to assess the progress and success of the scientist for interdisciplinary work?
2. Sharing Credit and Data: How will data sharing, processes for access to data, authorship decisions be reviewed and assessed?

Mentoring

1. How will the early career scientist be mentored in interdisciplinary research? (Individual mentor

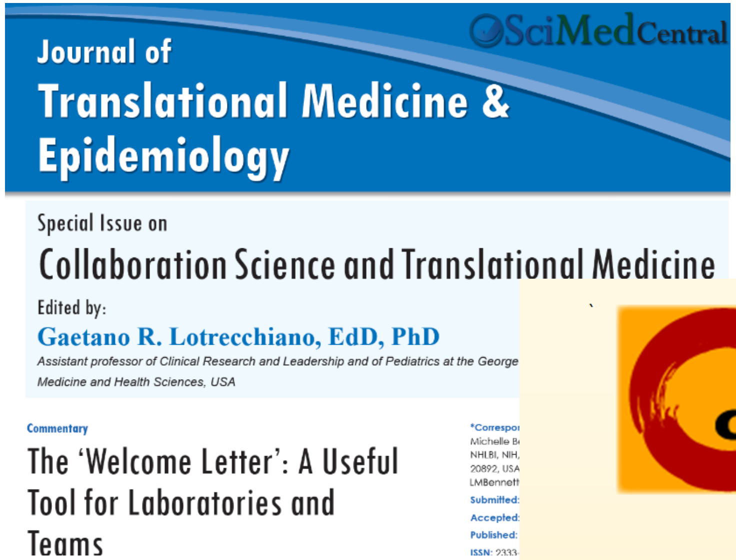
➤ **Team Scientist Track (variable amounts of effort distributed between research and education depending upon domain of activity)**

This track is for non-clinical faculty who make substantial contributions to the research and/or educational missions of the medical school. Faculty members whose primary activity is in research will typically engage in team science. Their skills, expertise and/or effort play a vital role in obtaining, sustaining and implementing programmatic research. Faculty on this track often have expertise in epidemiology, clinical trials, biostatistics, biomedical informatics, outcomes research or other qualitative and quantitative research methodologies and generally contribute to clinical studies, patient-oriented clinical outcomes research, community-engaged research, population-based studies and/or basic science research. Typically such faculty provide critical expertise to a program or group of research teams as a co-investigator with contributions that do not necessarily require or result in independent grant funding, but some fa
Faculty on this track do no ... f
missions of the medical sc ... ulty
their activity, for some me
focusing on education are ... in
development, degree prog ... gible
this track will be titled Assi
regular faculty track.

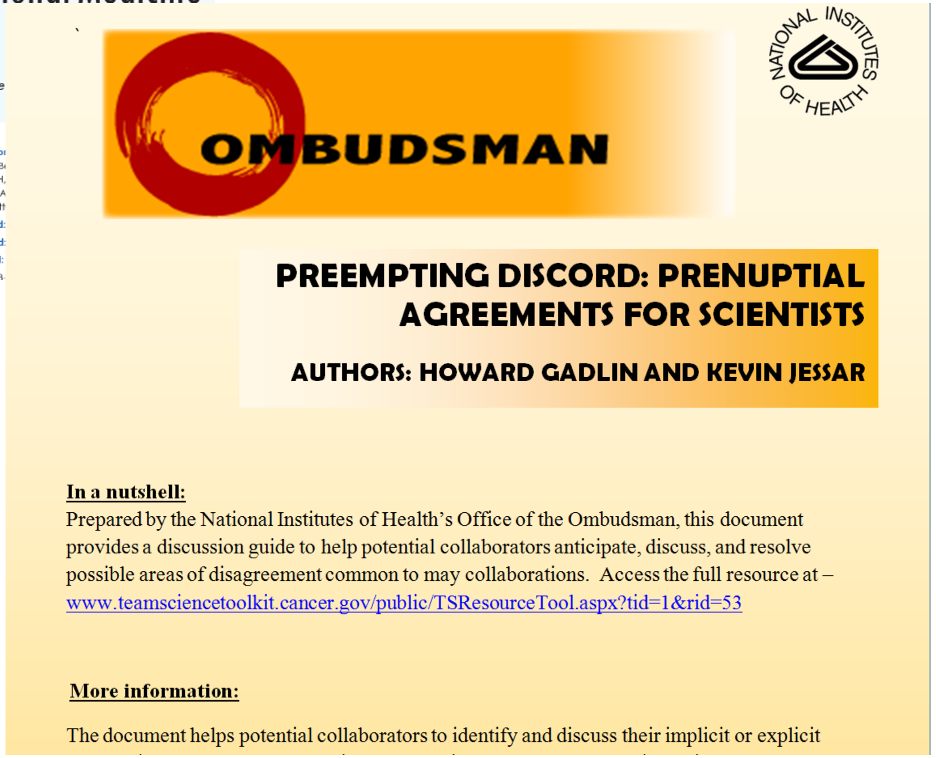
Career Track	Academic Title	Tenure Status*	Appt. Term in Years
Investigator	Professor	Tenured	
	Associate Professor	Tenured	
	Associate Professor w/o tenure	TE	3
	Assistant Professor	TE	3**
Clinician-Educator (full-time)	Professor	NTE	3***
	Associate Professor	NTE	3***
	Assistant Professor	NTE	3**
	Instructor	NTE	1
Clinician-Educator (part-time)	Professor	NTE	3***
	Associate Professor	NTE	3***
	Assistant Professor	NTE	3**
	Instructor	NTE	1
Team Scientist (full-time)	Professor	NTE	3***
	Associate Professor	NTE	3***
	Assistant Professor	NTE	3**
Team Scientist (part-time)	Professor	NTE	3***
	Associate Professor	NTE	3***
	Assistant Professor	NTE	3**
Research	Research Professor	NTE	1
	Research Associate Professor	NTE	1
	Research Assistant Professor	NTE	1

Tools For Setting Expectations, Preventing Conflict, and Planning For Success in TS

- ***Investigator level:***
- **“Welcome to my Team” Letter**
  - Provides a scaffold for building deeper trust including: what you can expect of the team, what the team expects of you, and what to do if we disagree



- ***Team level:***
- **Pre-collaboration Agreement (AKA Prenup for Scientists)**
  - Jointly created agreements among collaborators (formal or informal)



Tools For Setting Expectations, Preventing Conflict, and Planning For Success in TS

- ***Initiative level:* Operating Manual**
  - Describe expected roles, responsibilities, procedures, etc. for investigators and staff across research centers
    - Ideal for large, complex collaborations that may include multiple institutions/centers

Transdisciplinary Research on Energetics and Cancer

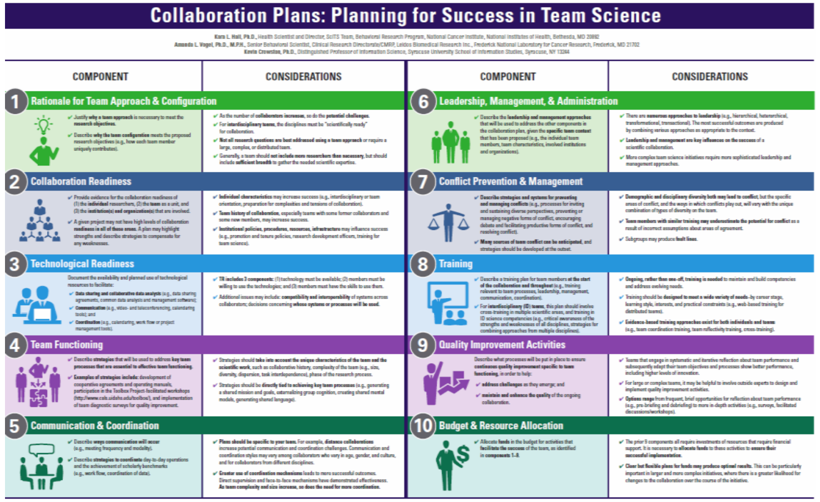
(TREC)

Manual of Operations

Version 2.6

January 28, 2010

- ***All levels:* Collaboration Plan**
  - Detailed plan that describes multi level ways the group will plan for and support effective collaboration



Collaboration Plans: Planning for Success in Team Science

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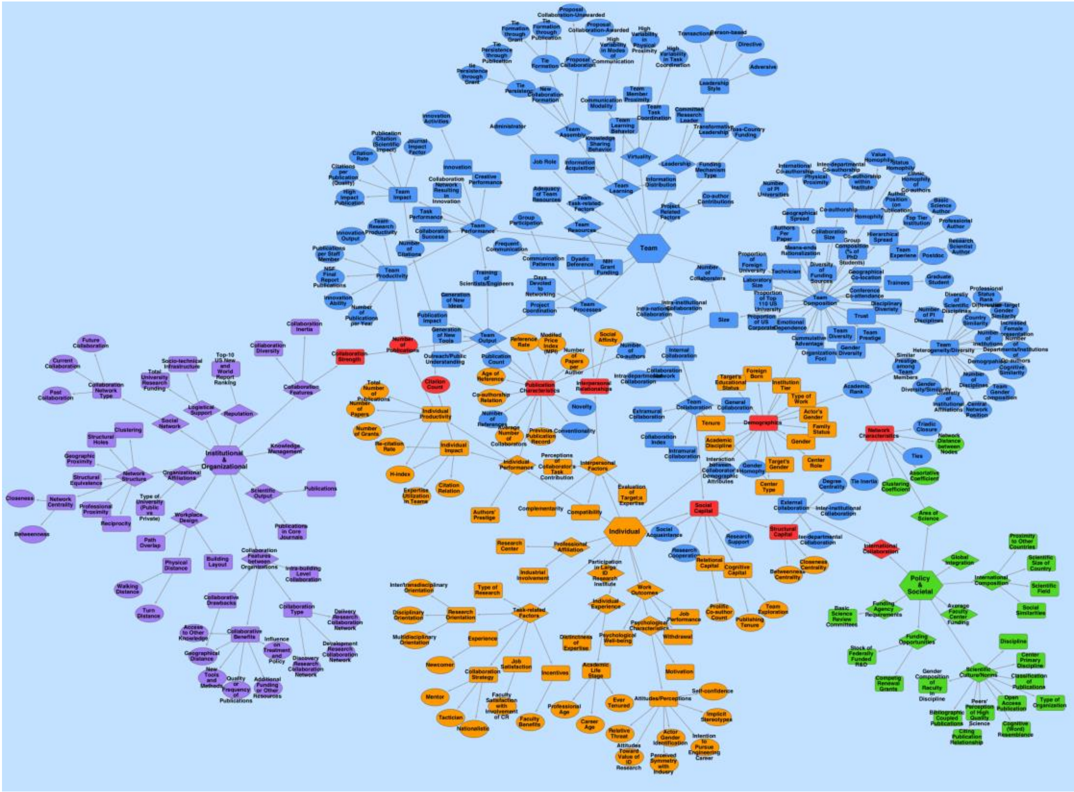
COMPONENT	CONSIDERATIONS
1 Rationale for Team Approach & Configuration	
✔ Justify **why a team approach** is necessary to meet the **research objectives.** ✔ Describe **why the team configuration** meets the proposed research objectives (e.g., how each team member uniquely contributes).	✔ As the number of **collaborators increases**, so do the **potential challenges.** ✔ For **interdisciplinary teams**, the disciplines must be "scientifically ready" for collaboration. ✔ **Not all research questions are best addressed using a team approach** or require a large, complex, or distributed team. ✔ Generally, a team should **not include more researchers than necessary**, but should include **sufficient breadth** to gather the needed scientific expertise.
2 Collaboration Readiness	
✔ Provide evidence for the collaboration readiness of (1) the **individual** researchers, (2) the **team** as a unit, and (3) the **institution(s) and organization(s)** that are involved. ✔ A given project may not have high levels of collaboration **readiness in all of these areas.** A plan may highlight strengths and describe strategies to compensate for any weaknesses.	✔ **Individual characteristics** may increase success (e.g., interdisciplinary or team orientation, preparation for complexities and tensions of collaboration). ✔ **Team history of collaboration**, especially teams with some former collaborators and some new members, may increase success. ✔ **Institutional policies, procedures, resources, infrastructure** may influence success (e.g., promotion and tenure policies, research development officers, training for team science).
3 Technological Readiness	
Document the availability and planned use of technological resources to facilitate: ✔ **Data sharing and collaborative data analysis** (e.g., data sharing agreements, common data analysis and management software); ✔ **Communication** (e.g., video- and teleconferencing, calendaring tools); and ✔ **Coordination** (e.g., calendaring, work flow or project management tools).	✔ **TR includes 3 components:** (1) technology must be available; (2) members must be willing to use the technologies; and (3) members must have the skills to use them. ✔ Additional issues may include: **competibility and interoperability** of systems across collaborators; decisions concerning **whose systems or processes will be used.**
4 Team Functioning	
✔ Describe **strategies** that will be used to address **key team processes that are essential to effective team functioning.** ✔ **Examples of strategies include:** development of cooperative agreements and operating manuals, participation in the Toolbox Project-facilitated workshops (http://www.cals.uidaho.edu/toolbox/), and implementation of team diagnostic surveys for quality improvement.	✔ Strategies should **take into account the unique characteristics of the team and the scientific work**, such as collaborative history, complexity of the team (e.g., size, diversity, dispersion, task interdependence), phase of the research process. ✔ Strategies should be **directly tied to achieving key team processes** (e.g., generating a shared mission and goals, externalizing group cognition, creating shared mental models, generating shared language).
5 Communication & Coordination	
✔ Describe **ways communication will occur** (e.g., meeting frequency and modality). ✔ Describe **strategies to coordinate** day-to-day operations and the achievement of scholarly benchmarks (e.g., work flow, coordination of data).	✔ **Plans should be specific to your team.** For example, **distance collaborations** increase potential communication and coordination challenges. Communication and coordination styles may vary among collaborators who vary in age, gender, and culture, and for collaborators from different disciplines. ✔ **Greater use of coordination mechanisms** leads to more successful outcomes. Direct supervision and face-to-face mechanisms have demonstrated effectiveness. **As team complexity and size increase, so does the need for more coordination.**

COMPONENT	CONSIDERATIONS
6 Leadership, Management, & Administration	
✔ Describe the **leadership and management approaches** that will be used to address the other components in the collaboration plan, given the **specific team context** that has been proposed (e.g., the individual team members, team characteristics, involved institutions and organizations).	✔ There are **numerous approaches to leadership** (e.g., hierarchical, heterarchical, transformational, transactional). The most successful outcomes are produced by combining various approaches as appropriate to the context. ✔ **Leadership and management are key influences on the success** of a scientific collaboration. ✔ More complex team science initiatives require more sophisticated leadership and management approaches.
7 Conflict Prevention & Management	
✔ **Describe strategies and systems for preventing and managing conflicts** (e.g., processes for inviting and sustaining diverse perspectives, preventing or managing negative forms of conflict, encouraging debate and facilitating productive forms of conflict, and resolving conflict). ✔ **Many sources of team conflict can be anticipated**, and strategies should be developed at the outset.	✔ **Demographic and disciplinary diversity both may lead to conflict**, but the specific areas of conflict, and the ways in which conflicts play out, will vary with the unique combination of types of diversity on the team. ✔ **Team members with similar training may underestimate the potential for conflict** as a result of incorrect assumptions about areas of agreement. ✔ Subgroups may produce **fault lines.**
8 Training	
✔ Describe a training plan for team members **at the start of the collaboration and throughout** (e.g., training relevant to team processes, leadership, management, communication, coordination). ✔ For **interdisciplinary (ID) teams**, this plan should involve cross-training in multiple scientific areas, and training in ID science competencies (e.g., critical awareness of the strengths and weaknesses of all disciplines, strategies for combining approaches from multiple disciplines).	✔ **Ongoing, rather than one-off, training is needed** to maintain and build competencies and address evolving needs. ✔ Training should be **designed to meet a wide variety of needs**—by career stage, learning style, interests, and practical constraints (e.g., web-based training for distributed teams). ✔ **Evidence-based training approaches exist for both individuals and teams** (e.g., team coordination training, team reflectivity training, cross-training).
9 Quality Improvement Activities	
Describe what processes will be put in place to ensure **continuous quality improvement specific to team functioning**, in order to help: ✔ **address challenges** as they emerge; and ✔ **maintain and enhance the quality** of the ongoing collaboration.	✔ Teams that engage in systematic and iterative reflection about team performance and subsequently adapt their team objectives and processes show better performance, including higher levels of innovation. ✔ For large or complex teams, it may be helpful to involve outside experts to design and implement quality improvement activities. ✔ **Options range** from frequent, brief opportunities for reflection about team performance (e.g., pre-briefing and debriefing) to more in-depth activities (e.g., surveys, facilitated discussions/workshops).
10 Budget & Resource Allocation	
✔ Allocate **funds** in the budget for activities that **facilitate the success** of the team, as identified **in components 1–9.**	✔ The prior 9 components all require investments of resources that require financial support. It is necessary to **allocate funds** to these activities to **ensure their successful implementation.** ✔ **Clear but flexible plans for funds may produce optimal results.** This can be particularly important in larger and more complex initiatives, where there is a greater likelihood for changes to the collaboration over the course of the initiative.

https://www.teamsciencetoolkit.cancer.gov/Public/TSResourceBiblio.aspx?tid=3&rid=3261

Team Science, Science of Team Science & Science of Teams

Multilevel Factors



Unique contextual conditions

- Legacy structures of academia
- Sources of support
- Rewards and incentives
- Success metrics
- Motivations for collaboration
- Collaborators who are also competitors