Science of Team Science: Informing Strategic Institutional Support

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Dean's Meeting – Oct 19, 2018

What is the evidence for the value of building diverse teams?

What is the power of diverse teams?

[diverse teams = broad range of team member characteristics - demographic, discipline, type of team members (e.g., scientist, community, patients, industry partners)]

Why we should deal with the
challenge of building and supporting diverse teams?

… because it seems pretty hard
to foster, build, and sustain diverse teams in science…

Battier Effect
(Daryl Morey, Rockets GM)

"His greatness is not marked in the box scores or at slam-dunk contests, but on the court **Shane Battier makes his team better**, often much better and his opponents worse often much worse."

New York Times, Feb 15, 2009

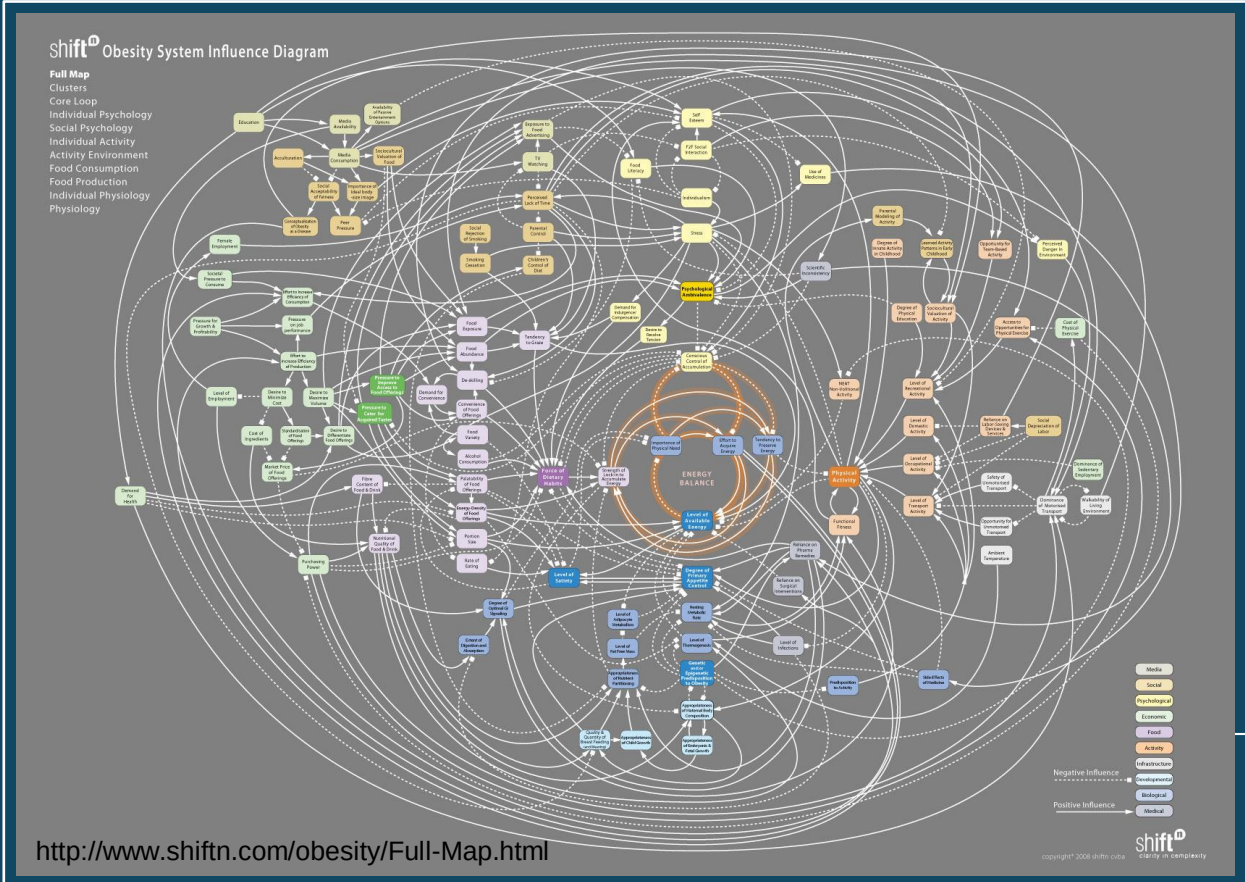
Rewards, Recognition, and Contracts

- "There is a tension, peculiar to basketball, **between the interests of the team and the interests of the individual**. The game continually tempts the people who play it to do things that are not in the interest of the group."

- "We think about this deeply whenever we're talking about **contractual incentives**… We **don't want to incent a guy to do things that hurt the team**" — and the amazing thing about basketball is how easy this is to do.

- "**They all maximize what they think they're being paid for**," he says. He laughs. "It's a tough environment for a player now because **you have a lot of teams starting to think differently. They've got to rethink how they're getting paid.**"

New York Times, Feb 15, 2009



Complex societal and scientific challenges

Multi-level, multi-factorial, interacting influences

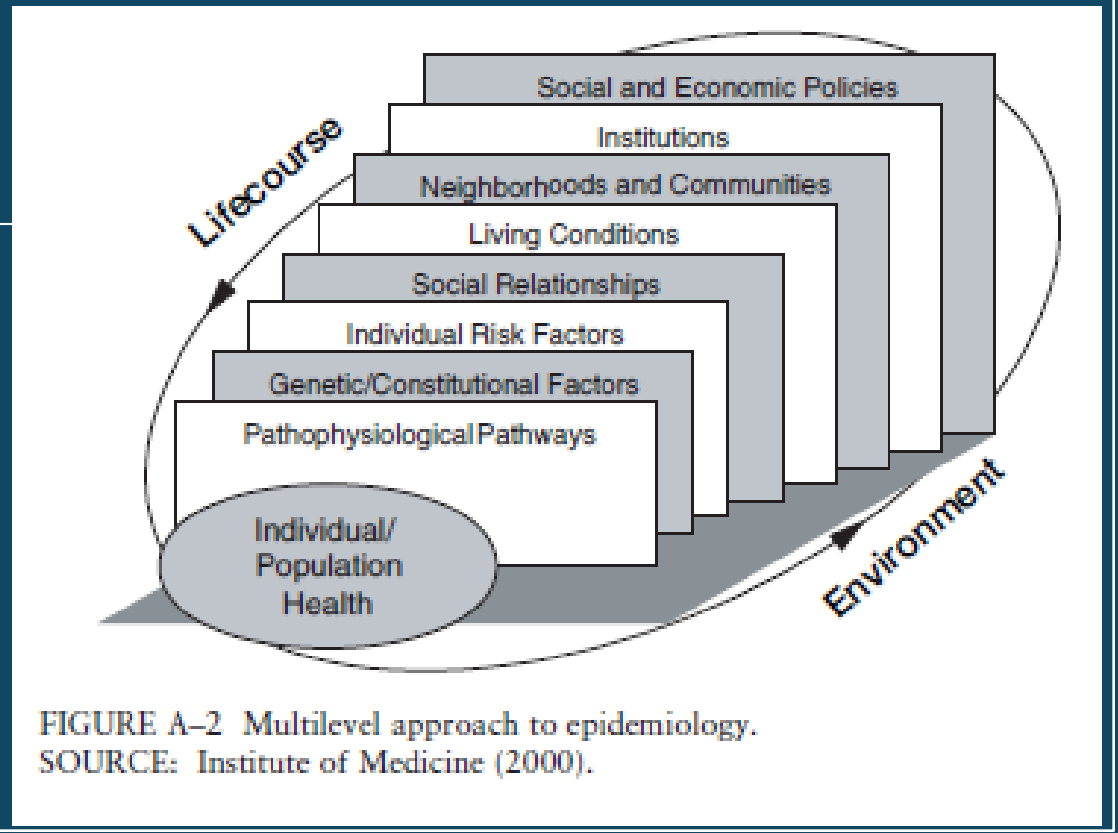
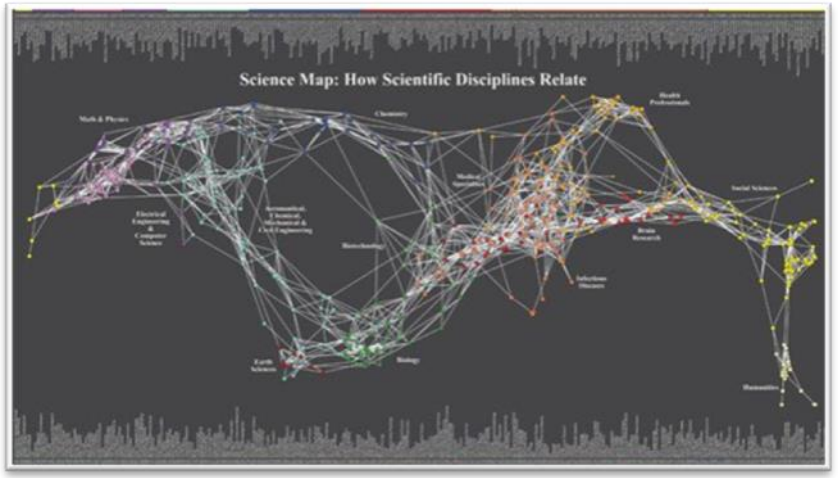
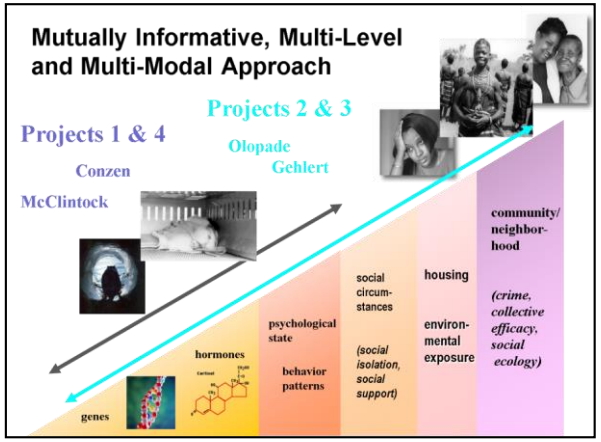


FIGURE A–2 Multilevel approach to epidemiology.
SOURCE: Institute of Medicine (2000).

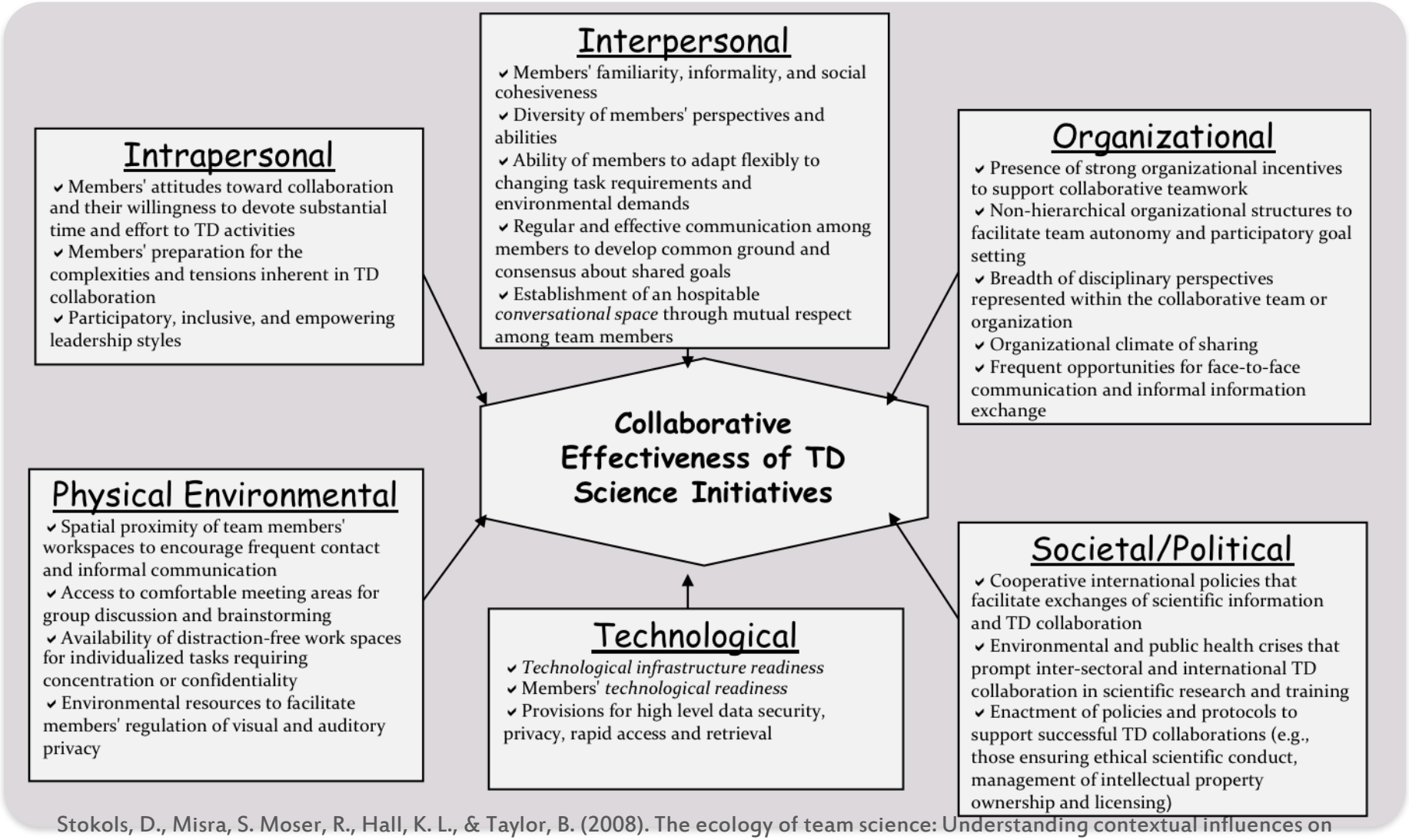
Variations in Team Science





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.

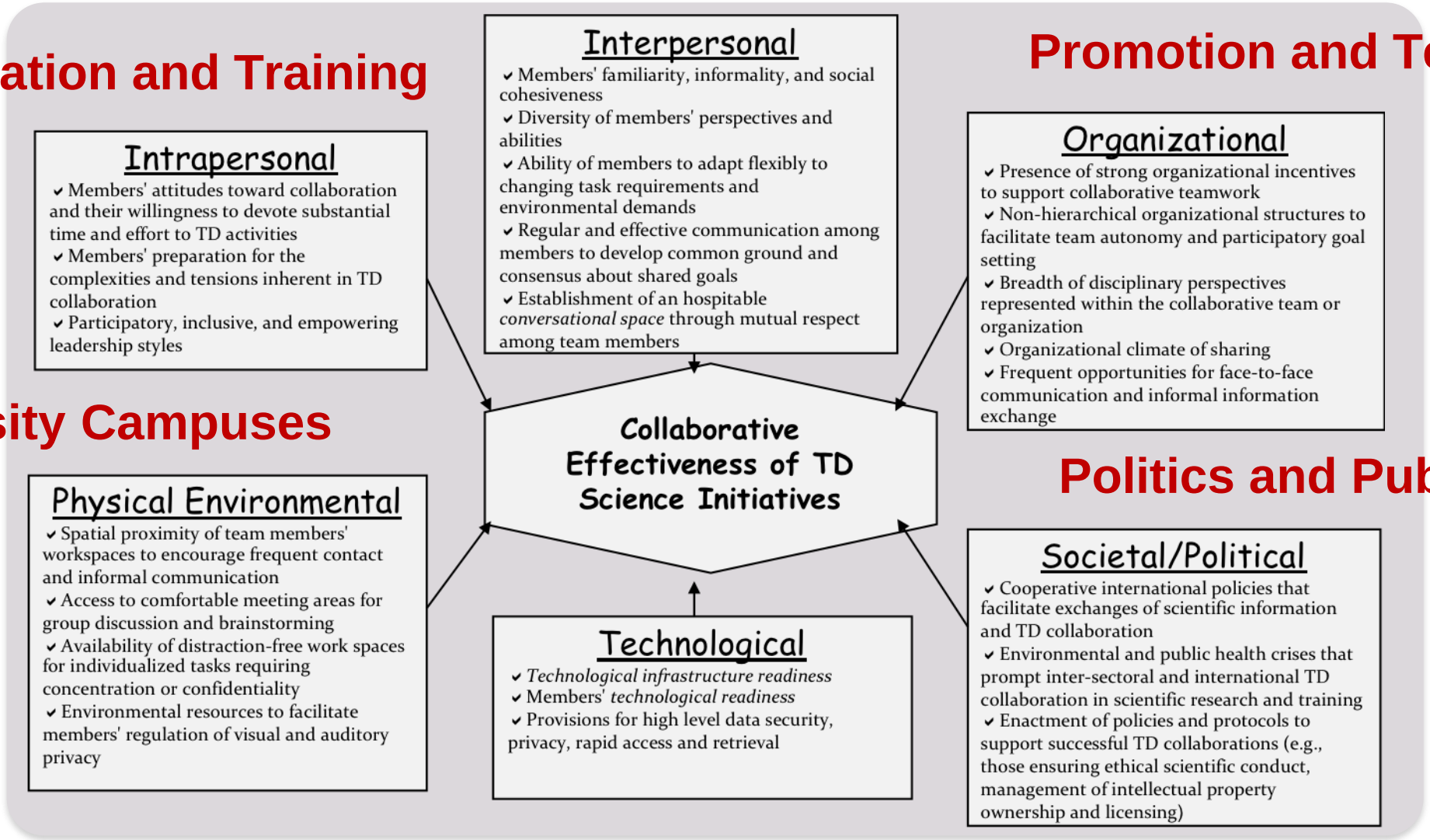
Constraints of Legacy Systems

Education and Training

Promotion and Tenure

University Campuses

Politics and Public Policy



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.

What might we ask ourselves?

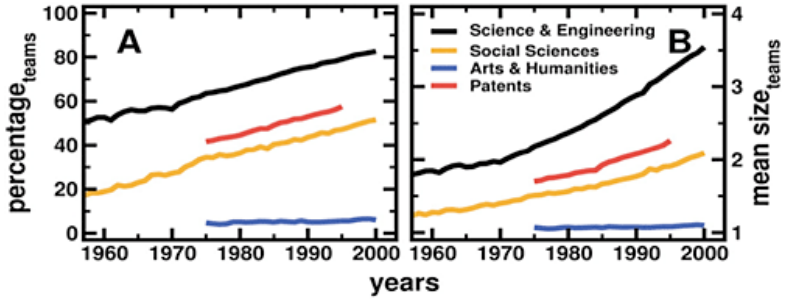
- What do we need to **advance science** and to **address** our **complex challenges**?
- ***Do* our recognition and rewards align** with those needs?
- ***How*** can we help to **better align** recognition and rewards with those needs?
- What are the opportunities to **shift culture**?
- How can we provide **structures to guide** those changes?
- **Do we know what we need to know** to offer clear guidance?

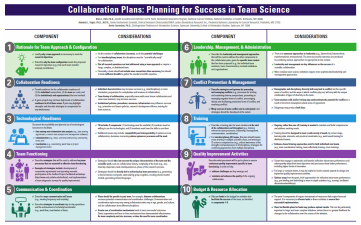
Image from: https://www.societyforscience.org/science-pain

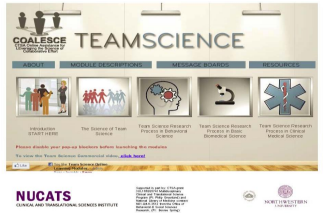
SciTS | Building the knowledge base for effective team science

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

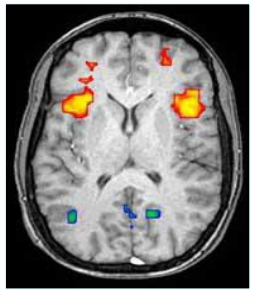
Psychology

Neuroscience

Genetics

•Candidate genes
•GWAS
•Functional studies

•fMRI
•PET
•Neuropsych assessment



Behavioral Science

•Quit success
•Therapeutic response
•Withdrawal signs

Pharmacology

Phase II-III Trials
•Existing meds
•Novel compounds

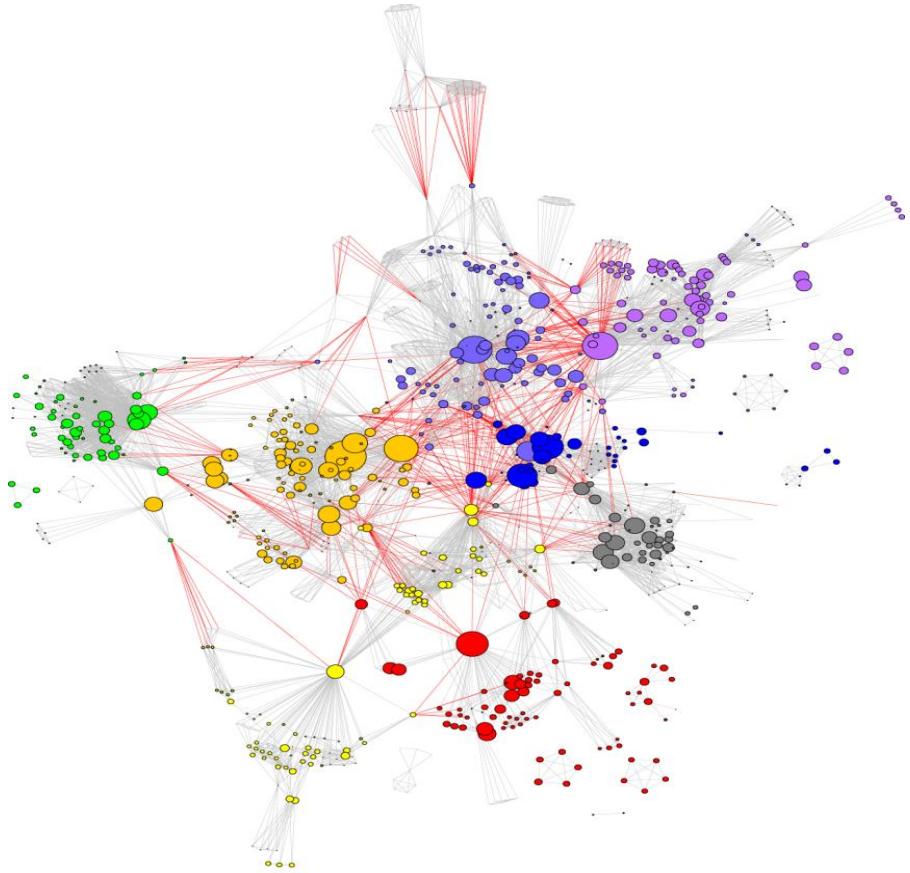
Goal: Development of targeted therapies for nicotine addiction

Adapted from Lerman, 2012

NCI Transdisciplinary (TD) Center Initiative

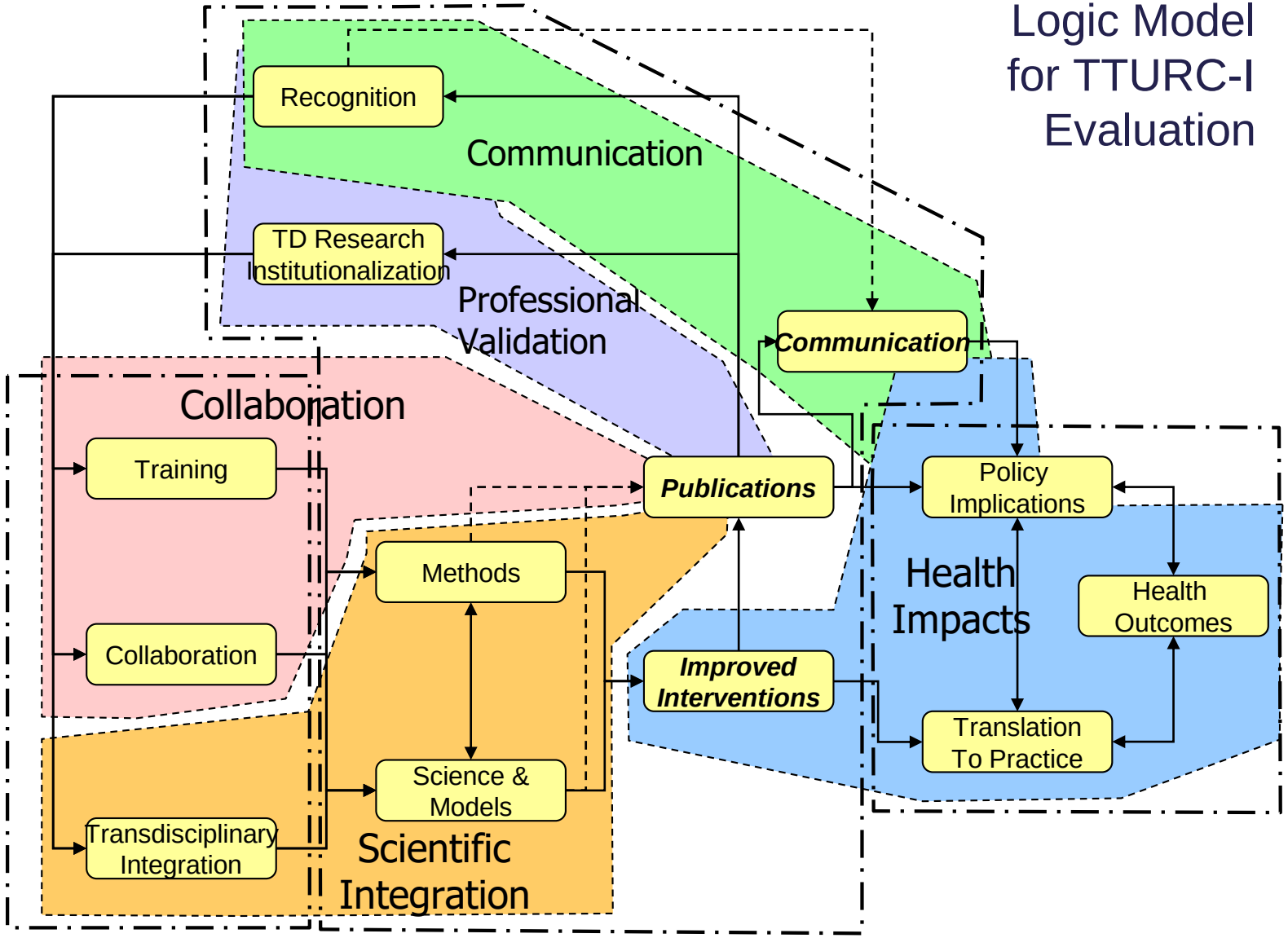
Transdisciplinary Tobacco Use Research Centers (TTURC)

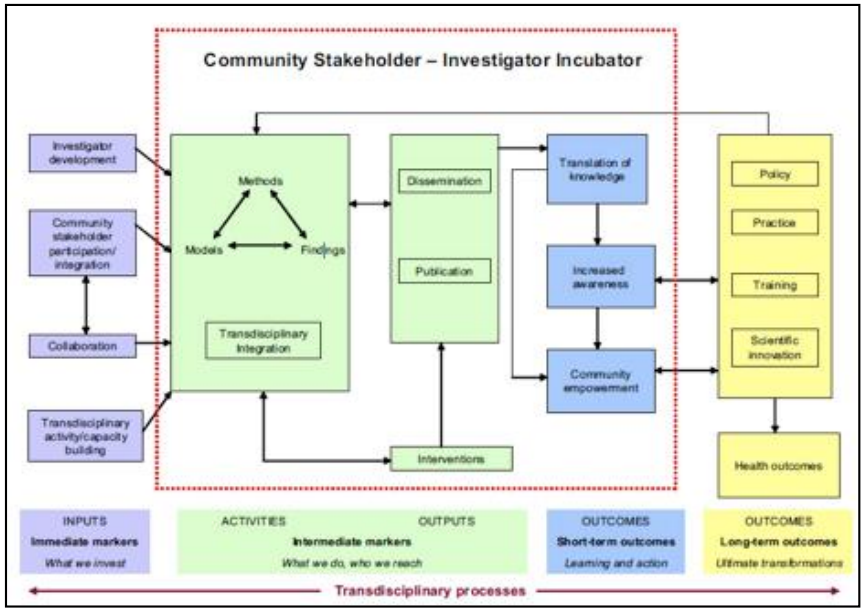
P50s - $68,995,753*

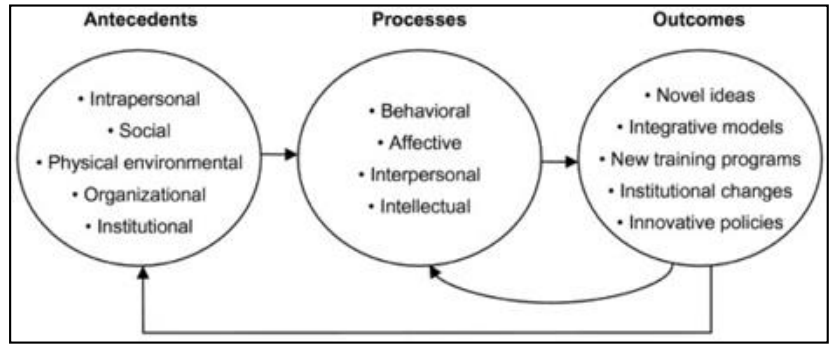


1999-2009

Logic Model for TTURC-I Evaluation

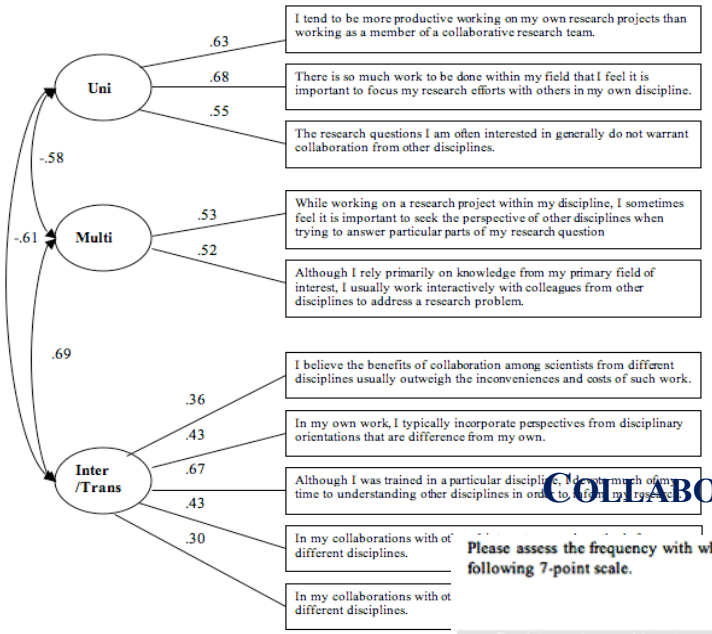




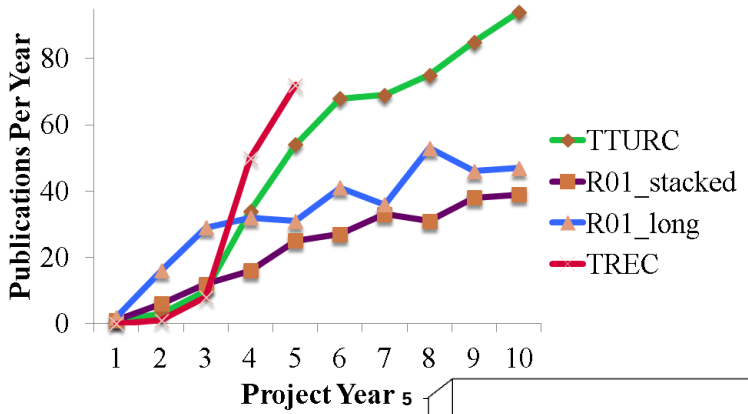


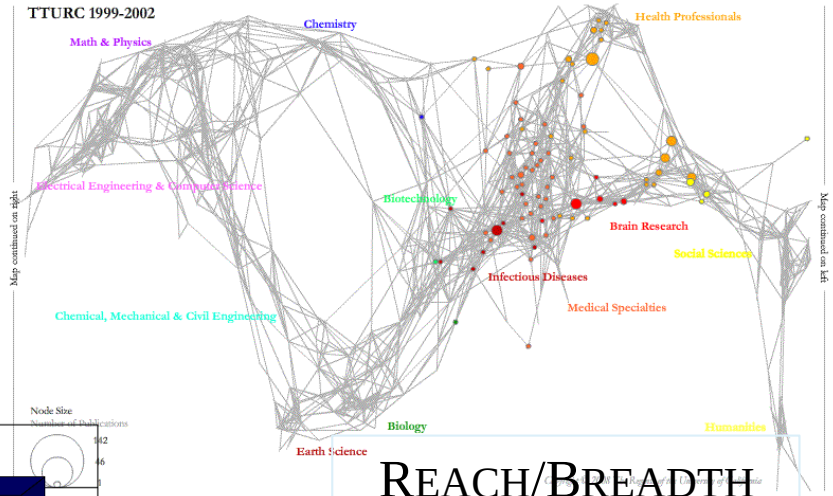
Hall, K. L., Stipelman, B. A., Vogel, A. L., & Stokols, D. (2017). Understanding cross-disciplinary team-based research: Concepts and conceptual models from the Science of Team Science. In Frodeman, R., Klein, J. T., & Mitcham, C. (Eds). *Oxford Handbook on Interdisciplinarity, 2nd Edition*. Oxford,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

Research Orientation Scale



Annual publications



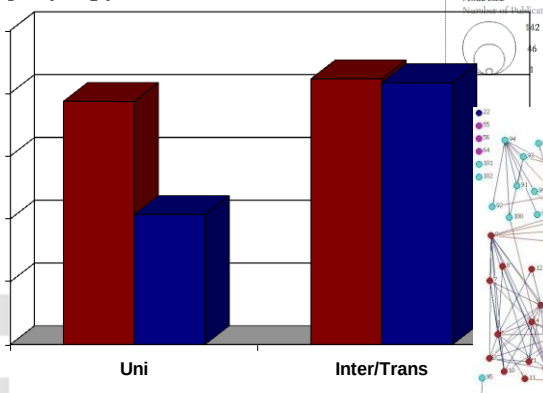


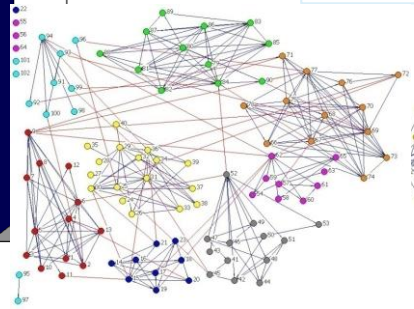
Reach/Breadth

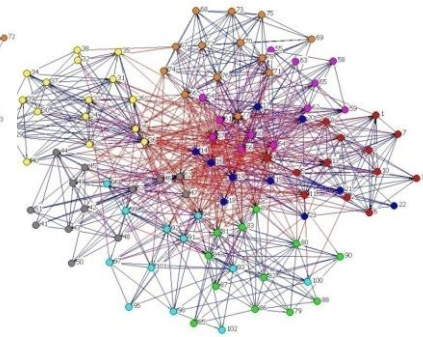
Collaborative Activities Scale

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

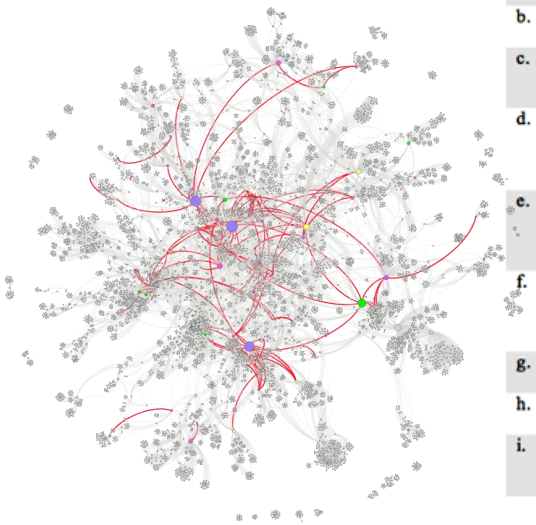
	Never	Rarely	Once a Year	Twice a Year	Quarterly	Monthly	Weekly
a. Read journals or publications outside of your primary field	☐	☐	☐	☐	☐	☐	☐
b. Attend meetings or conferences outside of your primary field	☐	☐	☐	☐	☐	☐	☐
c. Participate in working groups or committees with the intent to integrate ideas with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

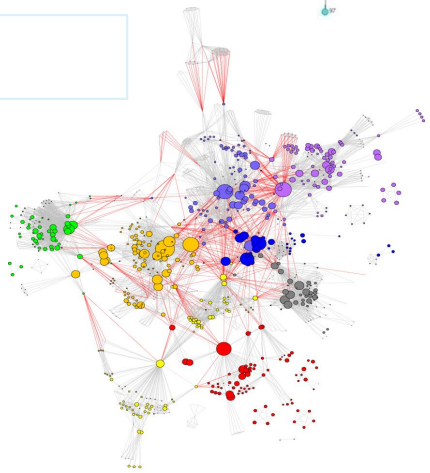


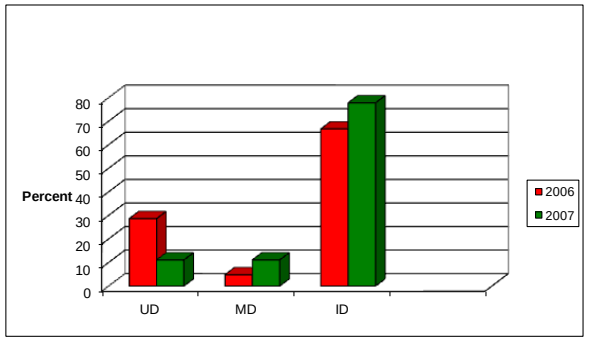




Individuals







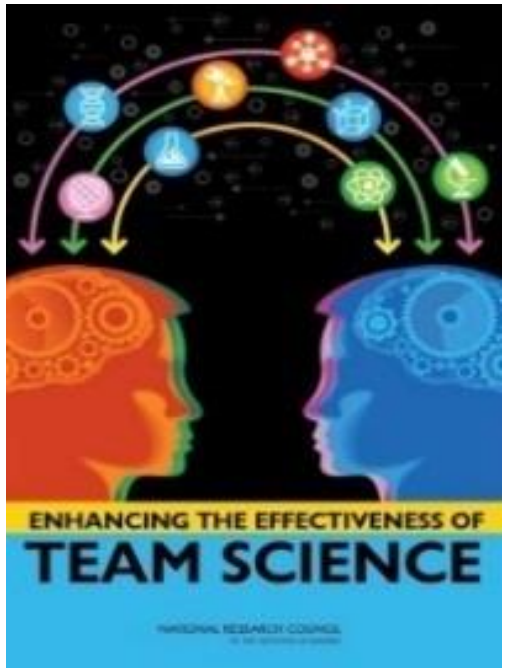
Levels of Analysis

Projects and Centers

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

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

"What is the **value of team science**? What does TS add over individually-driven science? (If anything….)"

"Do **cross-disciplinary** teams produce **more innovative science** than unidisciplinary teams?"

Administrators: "How do we create an **organizational environment** that fosters successful TS?"

Funders: "Is it a wise financial investment to **fund large teams**? Could it be more efficient to fund smaller investigator driven-grants?"

Researchers: "How do I go about **forming a new team**? And once I've done that, what **proven strategies** can I use to help us succeed?"

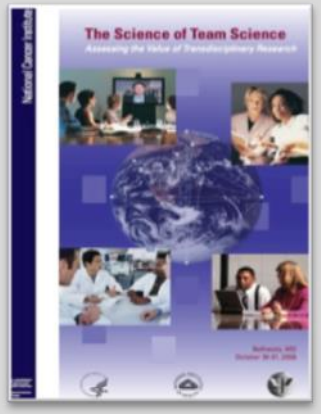
Researchers: "What approaches can I use to more easily **collaborate with colleagues from very different disciplines**?"

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.**

- **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?**

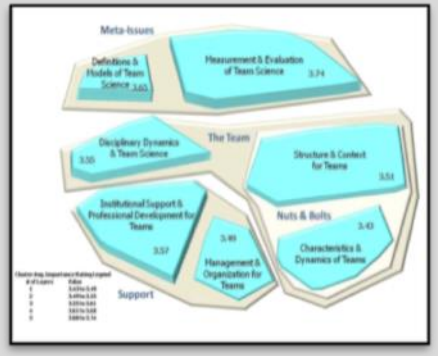
Building the SciTS Field

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

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

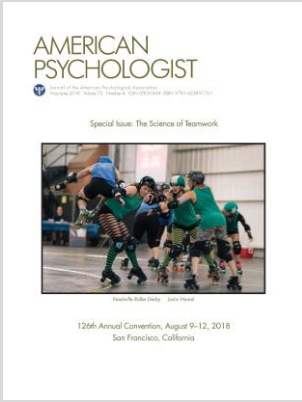
SciTS Journal Supplement

Team Approaches to Science, Practice, & Policy in Health

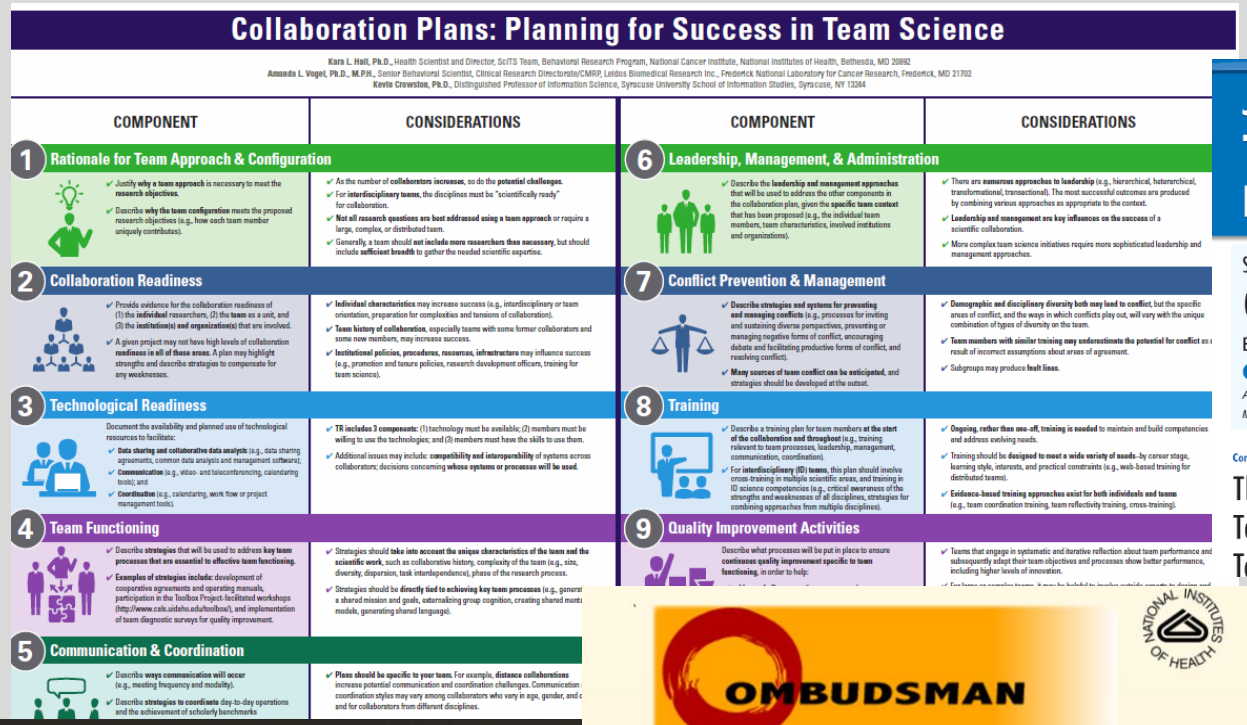
Collaboration Science & Translational Medicine

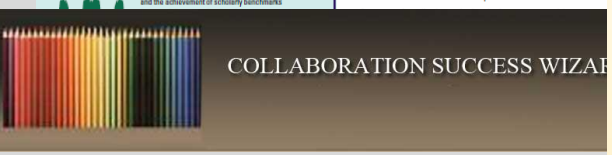
National Academies Consensus Study

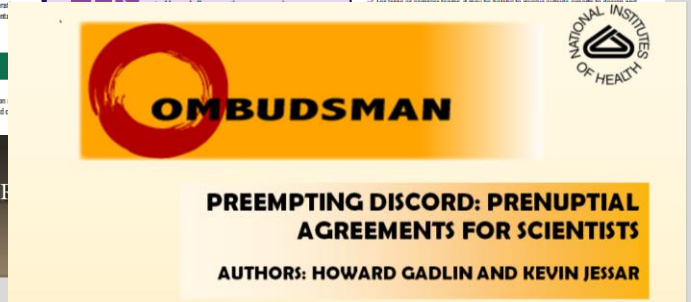
The Science of Team Science: A Review of the Empirical Evidence and Research Gaps on Collaboration in Science

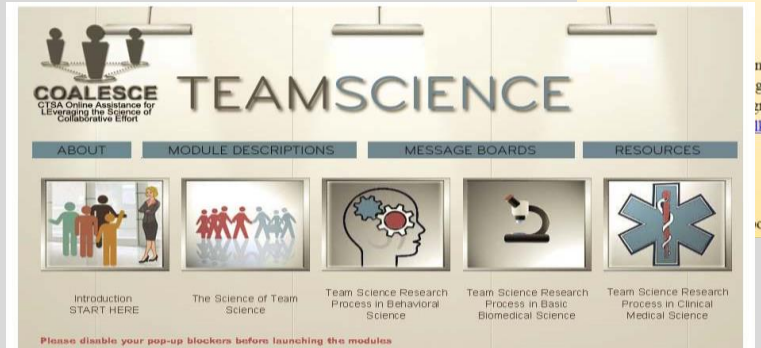


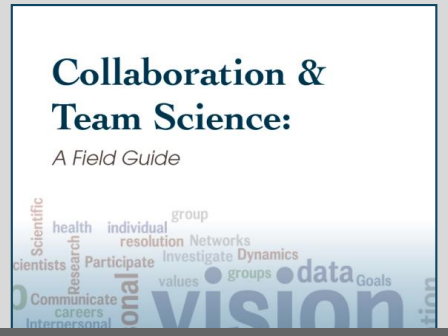
Developing Translational Applications











Boundary Spanning Collaborations

Greater Scientific Impact

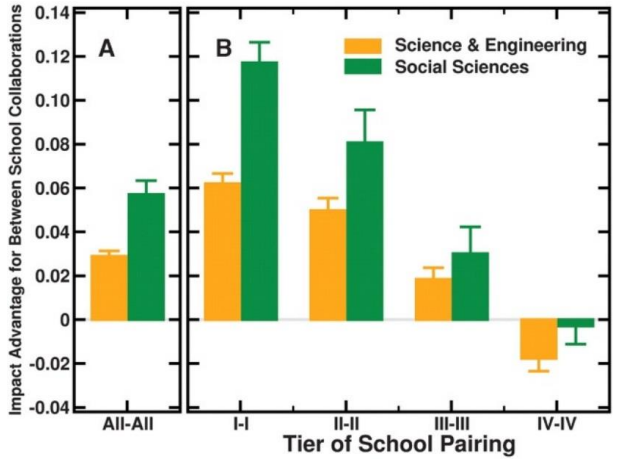
- ***Countries:*** International teams and teams from more locations generally yield **higher impact publications**
  - with certain countries (e.g., US) and universities (R1) increasing the likelihood of positive impacts

- ***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.



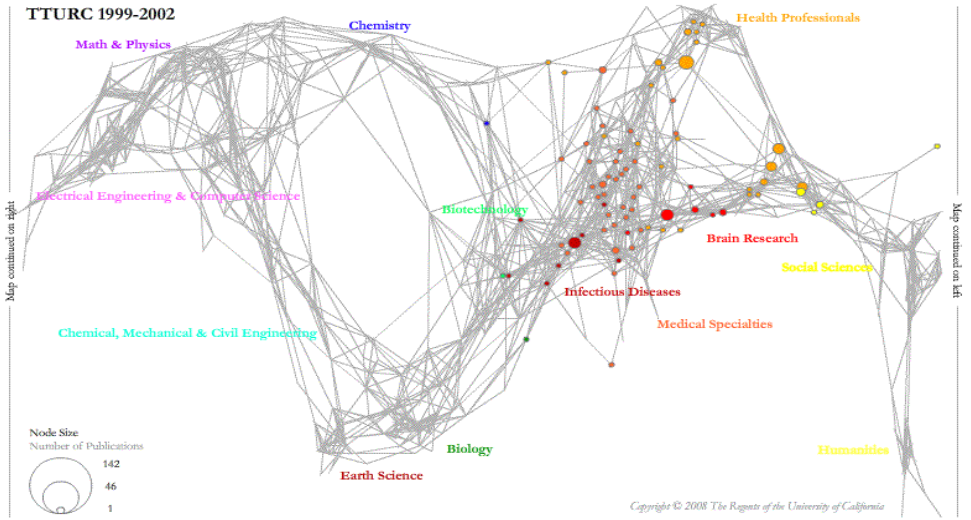
Hall, K. L., Vogel, A. L., Huang, G. C., Serrano, K. J., Rice, E. L., Tsakraklides, S. P., & Fiore, S. M. (2018). The science of team science: A review of the empirical evidence and research gaps on collaboration in science. *American Psychologist*, 73(4), 532-548.

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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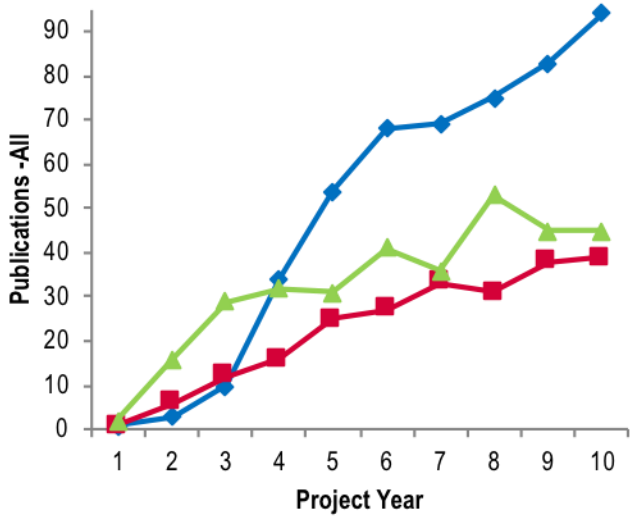
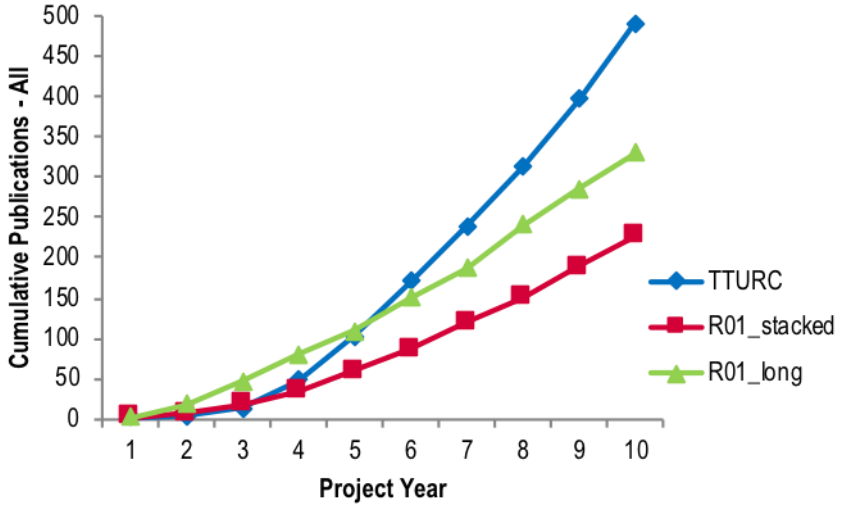
Productivity of TD Center Grants and R01 Investigator-Initiated Grants

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.**

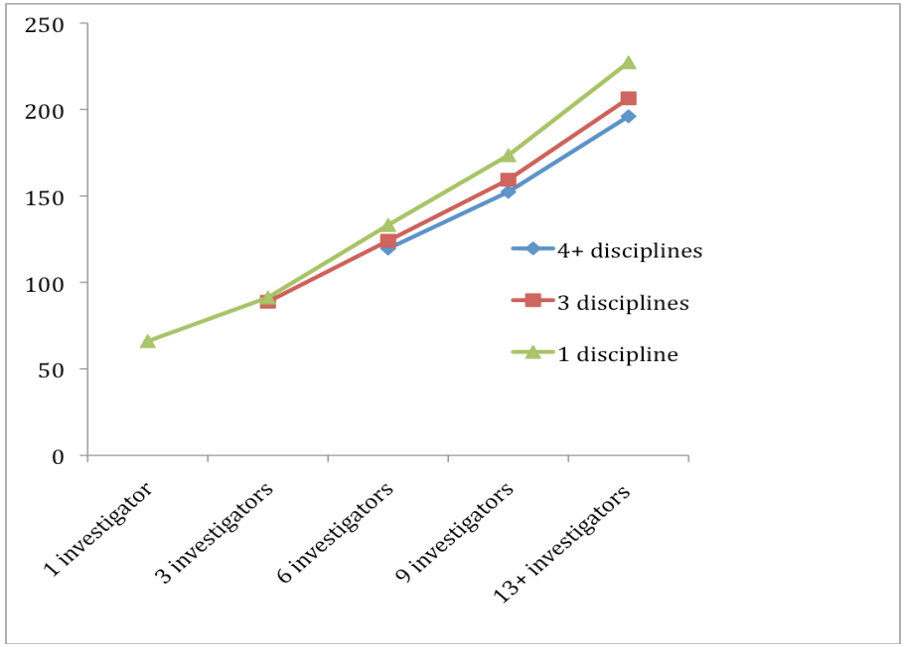
Method: Quasi-experimental design comparing number of publications of TTURC initiative with matched R01 projects from the tobacco field over 10-year period

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.

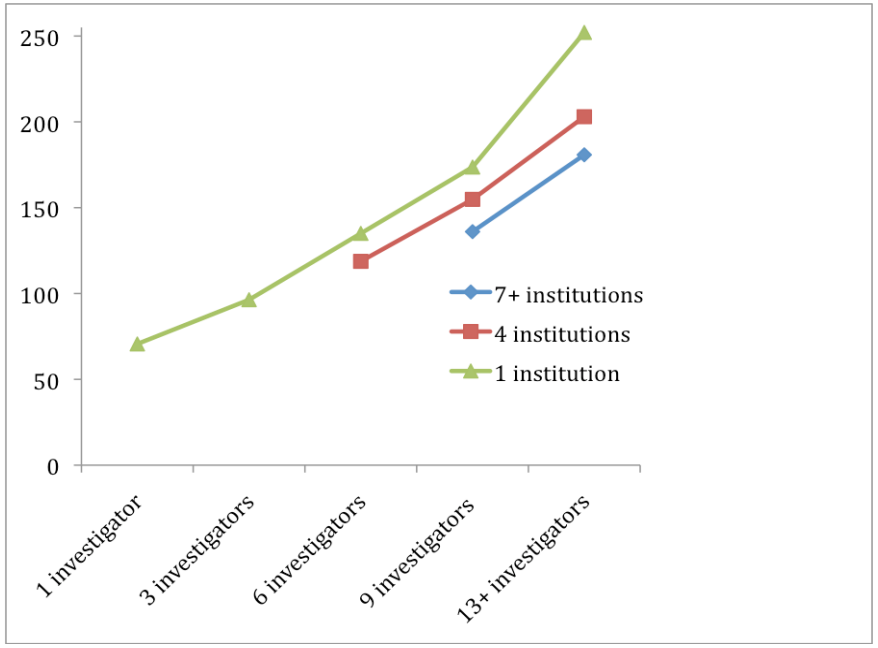
Multi-disciplinary & Multi-Institutional

Team Science Productivity

Predicted # of publications as a function of research group size &heterogeneity as measured by # of disciplines of the investigators



Predicted # of publications as a function of research group size &group heterogeneity as measured by # 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 - **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***

Summary Points

- 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.

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

Summary Points

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.

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**

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 with project funding**
  - 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.

Transdiciplinary Research on Energetics and Cancer

116+ investigators
30+ disciplines
5 sites

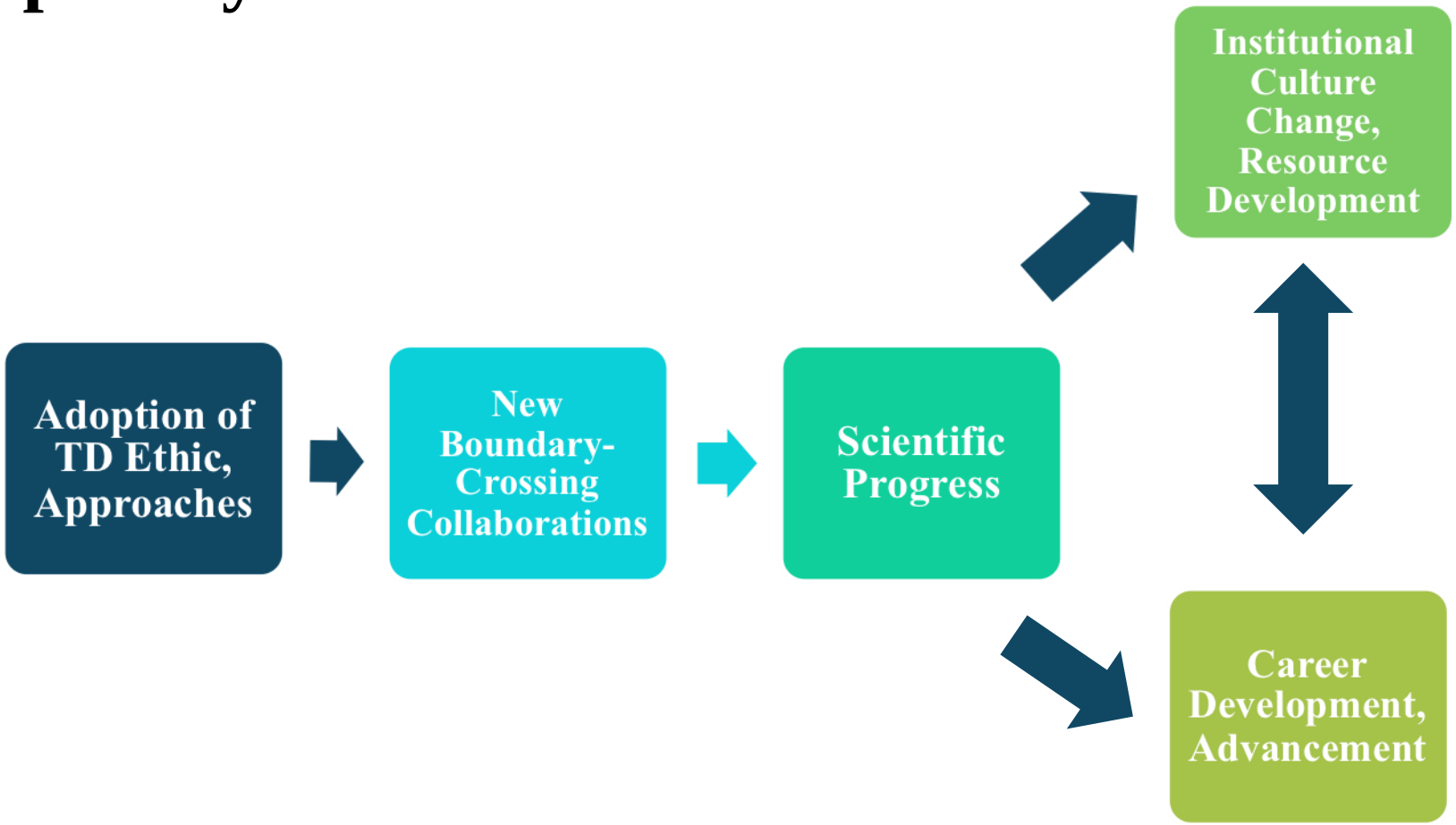
Biochemistry
Genetics
Statistics
Medicine
Social Work
Psychology
Epidemiology
Physical Therapy
Occupational Therapy
Molecular Biology
Systems Science
Urban Planning
Anthropology
Economics
Nutrition
Sociology
Metabolism
Etc.

Challenges in Transdisciplinary 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 Transdisciplinary Research Initiative



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.

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)

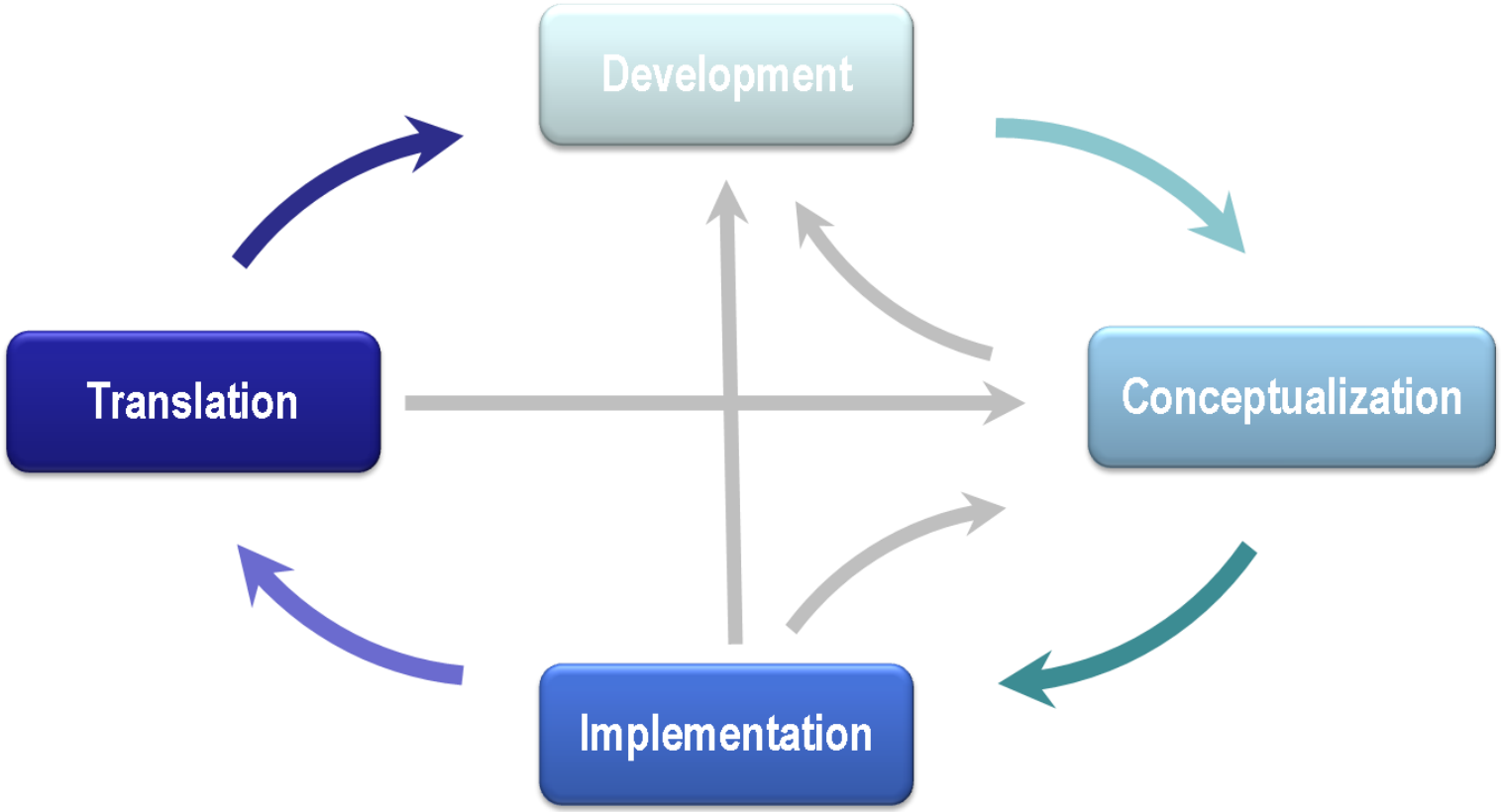
Findings help to illustrate:

- 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

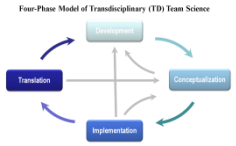
Build on emerging evidence and lessons learned to most effectively and efficiently advance our science

- 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

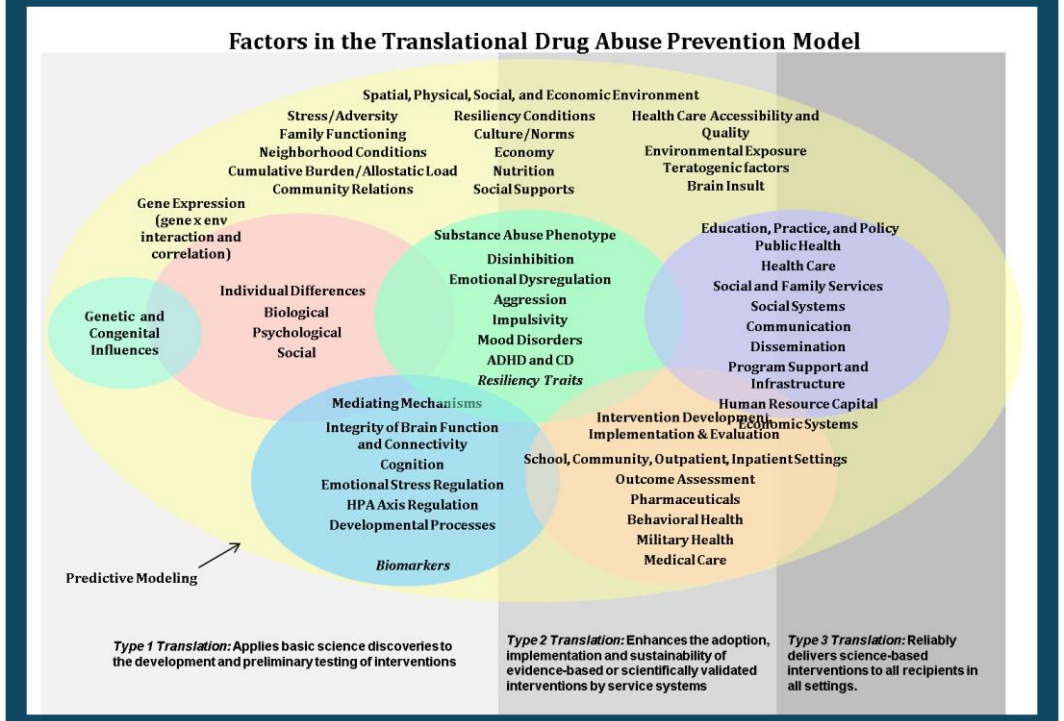
Goal: Define the scientific or societal **problem space** of interest, including identifying the intricacies & interconnections of concepts that fall within the problem space & establishing the boundaries of the problem space to be addressed

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

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

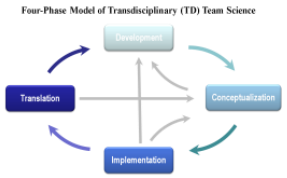
Team Type:

- 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



Conceptualization Phase

Goals & Key Processes

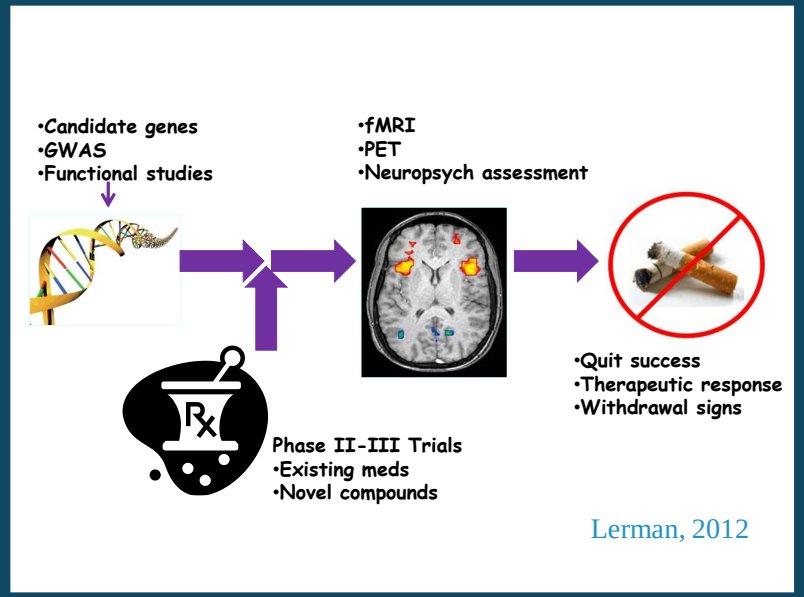
Goal: Develop novel research questions, hypotheses, & a conceptual framework & research design that integrate collaborators' disciplinary perspectives & knowledge domains to address the target problem in innovative ways.

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**

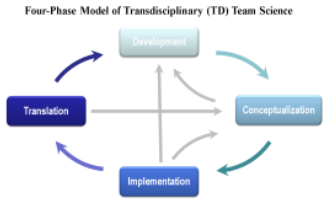
Team Type:

- Emerging team, evolving team



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

- Encourage use of glossary
- Yellow cards



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)

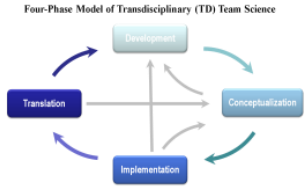
Team Type:
Real team

"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
- **Clear understanding of team membership**

West et al, 2011; West & Lyubovikova, 2012



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

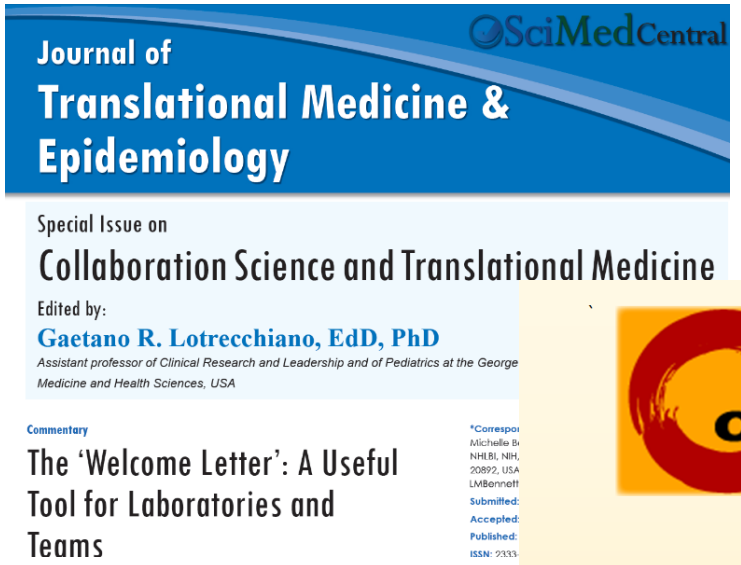
Source: Hall, KL, Vogel, AL, Stipelman, B, Stokols, D, Morgan, G, & Gehlert, S. (2012). A Four-Phase Model of Transdisciplinary Research : Goals, Processes and Strategies. *Translational Behavioral Medicine, 2* (4).

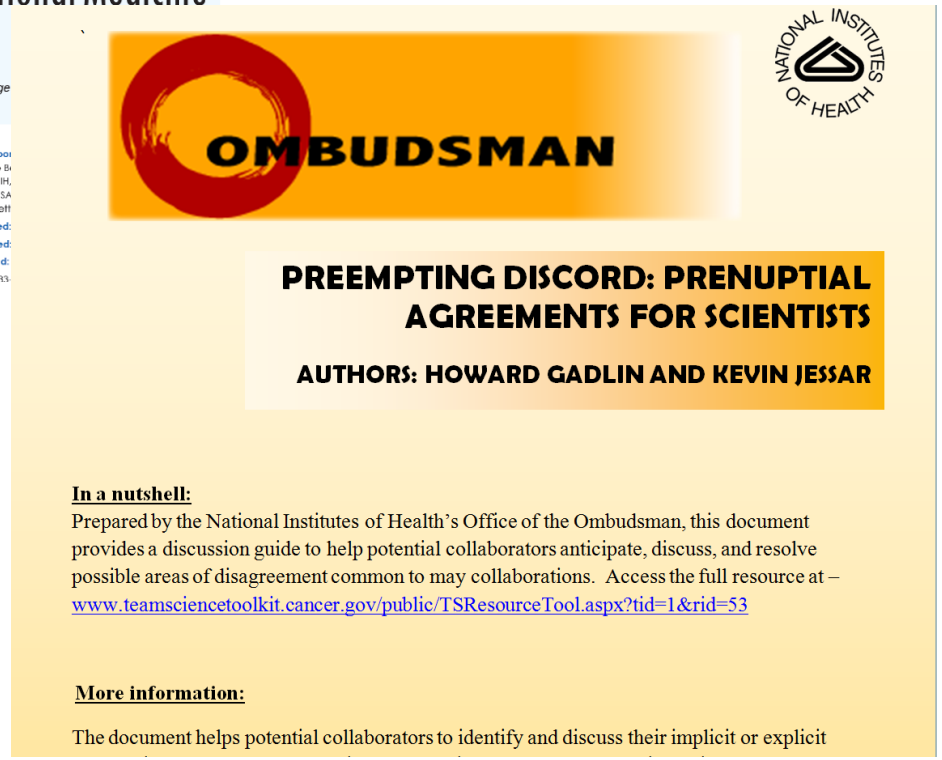
Practical and Strategic Considerations

1. Support the identification, adaptation, and use of **tools and resources**
2. Consider elements of a **Collaboration Plan** that your university can bolster
3. Address need for personnel (faculty/staff/students) with **team science competencies**
4. Support **Development Phase** work
5. Identify ways to support / recognize the value of **setting and maintaining strategic visions**
6. Align **Promotion and Tenure** policies with team science

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

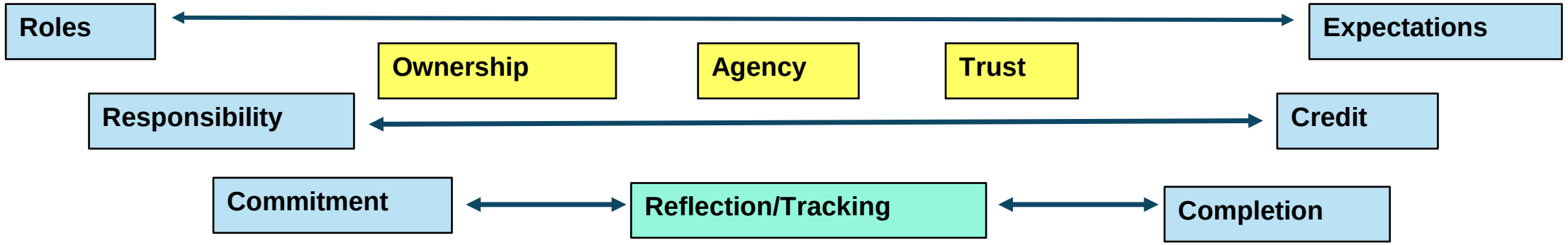
- ***Investigator level:***
- **"Welcome to my Team" Letter**
  - Provides a scaffold for building deeper trust including: what you can expect of the team, what the team expects of you, and what to do if we disagree





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

Clarification and Commitment



Roles and Responsibility Documentation – Living document

- Starting Roles/Responsibility
- Secondary & Emerging Roles/Responsibility
- Member Commitments
- Tracking of Responsibilities and Accomplishments.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NEW RESEARCH IN Physical Sciences Social Sciences

Transparency in authors' contributions and responsibilities to promote integrity in scientific publication

Marcia K. McNutt, Monica Bradford, Jeffrey M. Drazen, Brooks Hanson, Bob Howard, Kathleen Hall Jamieson, Véronique Kiermer, Emilie Marcus, Barbara Kline Pope, Randy Schekman, Sowmya Swaminathan, Peter J. Stang, and Inder M. Verma

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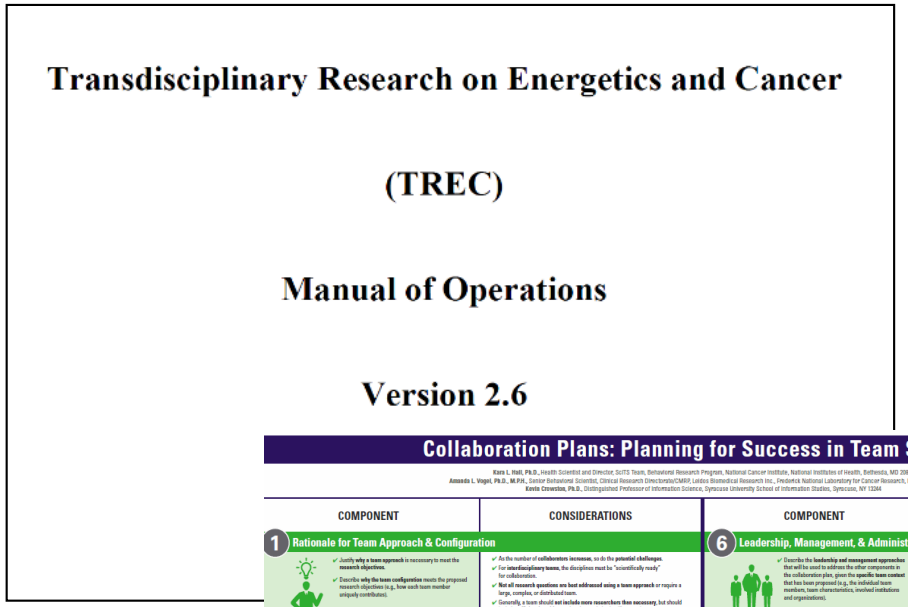
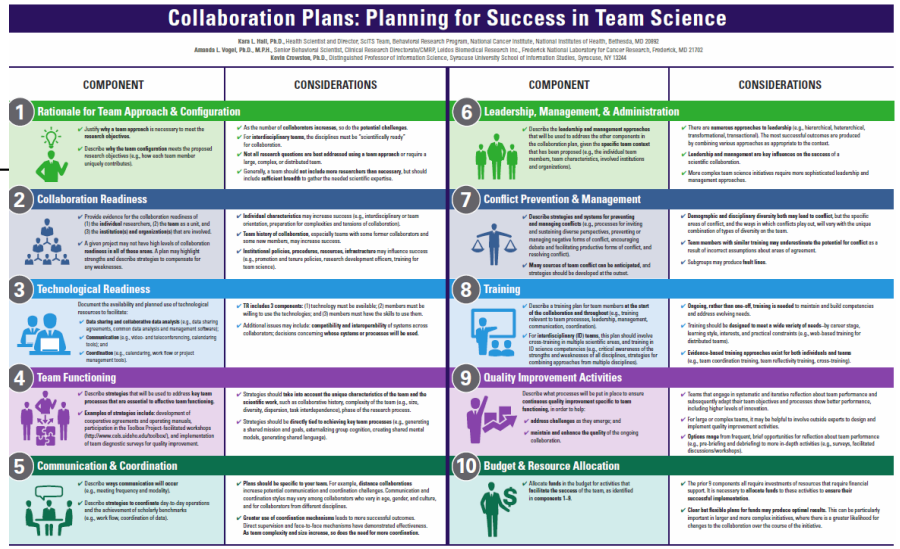
Edited by Karen S. Cook, Stanford University, Stanford, CA, and approved January 18, 2018 (received for review August 30, 2017)

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

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





https://www.teamsciencetoolkit.cancer.gov/Public/TSResourceTool.aspx?tid=1&rid=371;
https://www.teamsciencetoolkit.cancer.gov/Public/TSResourceBiblio.aspx?tid=3&rid=3261

Collaboration Plans: Planning for Success in Team Science

Kara L. Hall, Ph.D., Health Scientist and Director, SciTS Team, Behavioral Research Program, National Cancer Institute, National Institutes of Health, Bethesda, MD 20892
Amanda L. Vogel, Ph.D., M.P.H., Senior Behavioral Scientist, Clinical Research Directorate/CMRP, Leidos Biomedical Research Inc., Frederick National Laboratory for Cancer Research, Frederick, MD 21702
Kevin Crowston, Ph.D., Distinguished Professor of Information Science, Syracuse University School of Information Studies, Syracuse, NY 13244

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: **compatibility 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.**
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

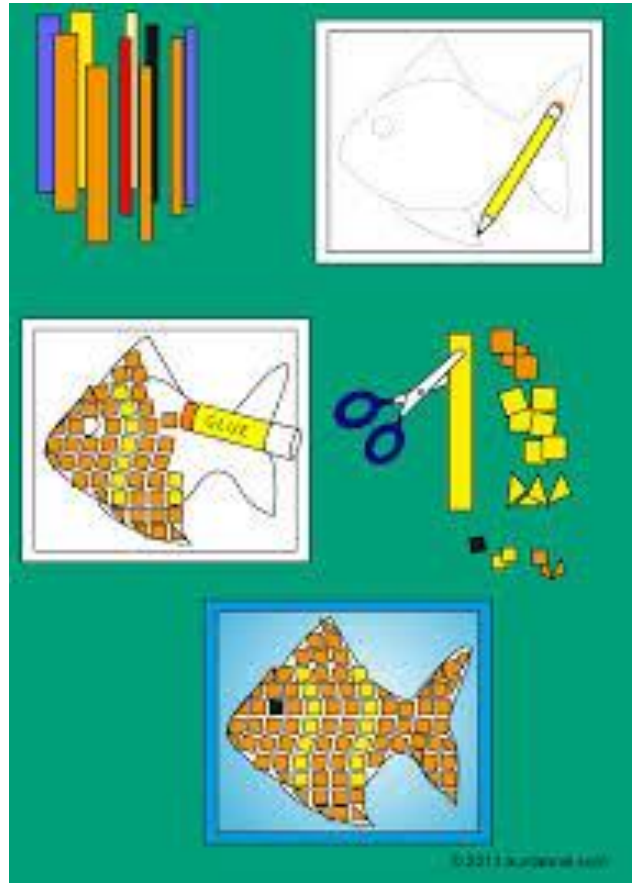
Structure/Process for Scientific Content

Map charge/ problem space	Deconstruct work/ problem space	Configure People/Process	Create micro products	Validate/ Integrate	Iterate content/ process

Division of responsibility to avoid diffusion of responsibility

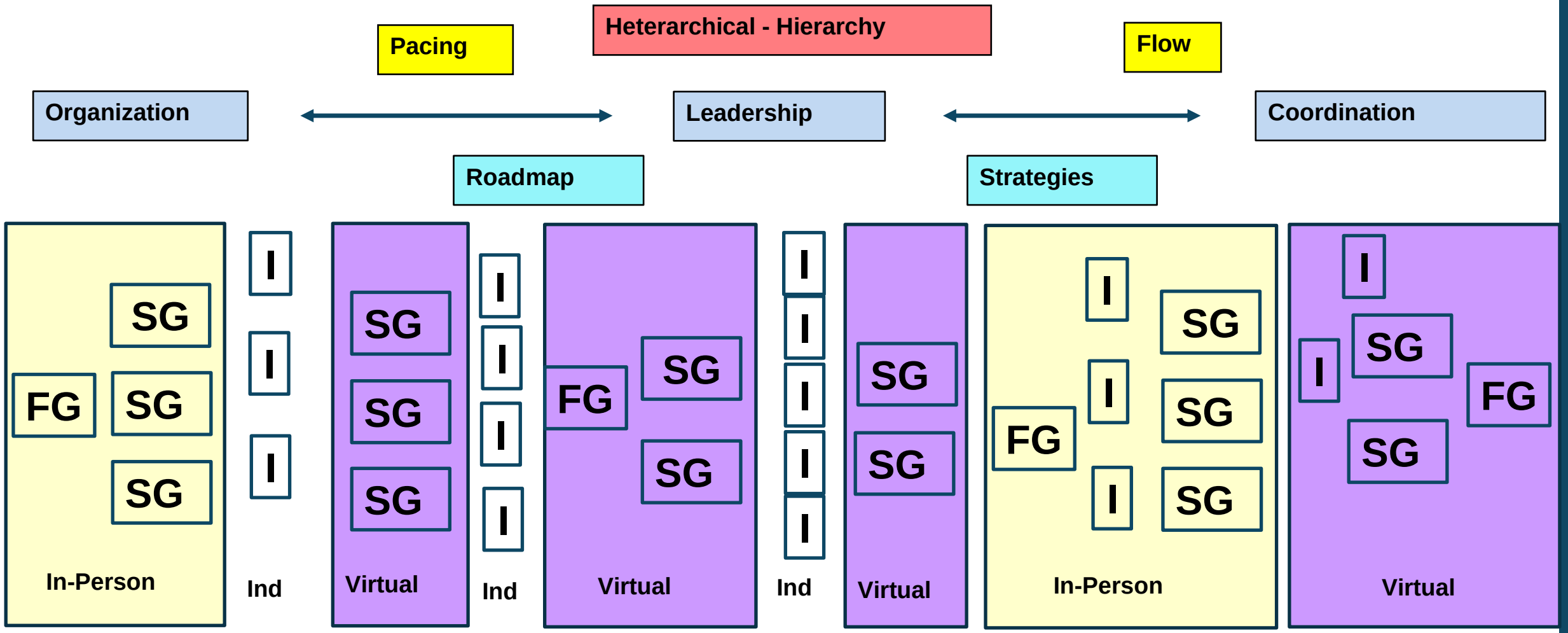
Collaborators are involved in endless projects and committees… this results in challenges of imbalance of work or lost opportunities

- Breakdown the objectives/projects into series of tasks
- Explication of the multiplicity of roles
- Divide into subgroups to complete tasks
- Provide explicit templates, structure
- Process for moving between full group, subgroup and independently



Kindergarten Model

Structure/Process for Organization and Production in Scientific Groups



Identification of info needed for decision making

Info gathering

Individual reflection

Collaborative writing - world cafe

Pre-work – during-work – post-work

FG=Full Group; SG=Subgroup

Support for Coordination and Management

What are the challenges?

- Inadequate appreciation of how poor coordination mechanisms influences scientific outcome, Yet **when project budgets are cut 20-30% the first items eliminated** were (Cummings & Keisler, 2005):
  - support for coordination and knowledge transfer activities – e.g., support of postdoctoral fellows, project managers, seminars, and workshops.
- Inadequate coordination, administration, management infrastructure within institutions/projects

What is needed?

- Competencies need to be covered – solutions depend on size and complexity of teams
- 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

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 –

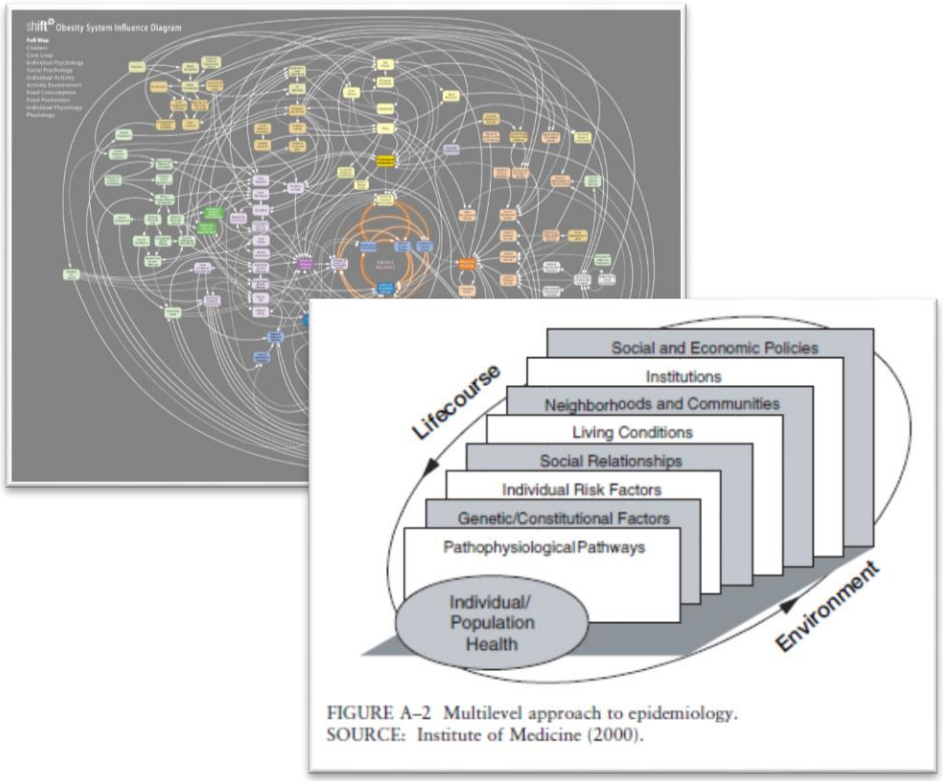


FIGURE A–2 Multilevel approach to epidemiology.
SOURCE: Institute of Medicine (2000).

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

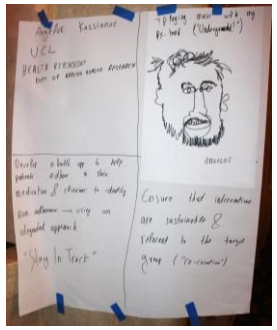
- NCI, NSF, DOD, NAS supporting Ideas labs

Facilitating Novel Projects and Teams – Process Matters

Setting the Stage

Picasso in a Bag

Pair Introductions



Speakers - Speed dating

Idea Generation

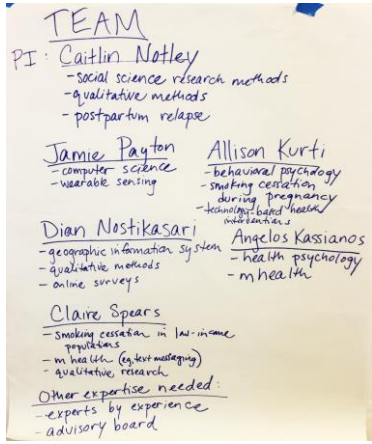
Questions, Clustering, Teaming

Mental Models

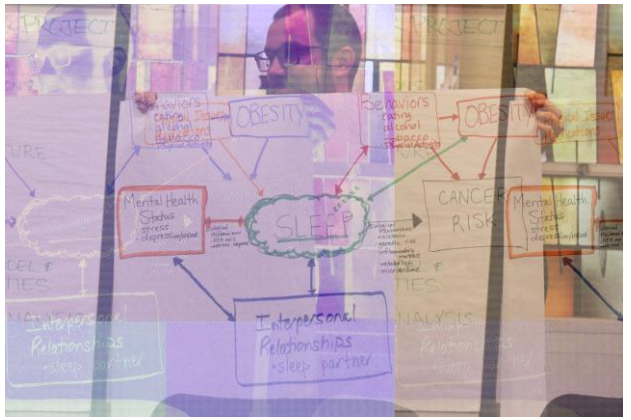
Feedback – Soap boxes

Project Development

Team Formation



Project Pitches



Expert Review - Funding

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 & 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

"Real" vs "Pseudo" team

Characteristics that lead to increased performance & innovation:

- **Interdependence**

  Pooled, sequential, reciprocal

- **Iterative reflection**

  Systematic consideration of team performance & participation in related adaptation to team goals & processes

- **Clear understanding of team membership**

West et al, 2011; West & Lyubovikova, 2012

Promotion and Tenure Criteria for Evaluation of TS and/or ID Research Contributions

1. **Independence** within or regardless of involvement in a team
2. **Reputation** for being a team researcher or in spite of involvement of team
3. **Leadership** in or leadership of a collaboration
4. Demonstrating **TS & ID skills and competencies**

Promotion and Tenure

Disciplinary-oriented Independent Scientist	Transdisciplinary Team Scientist
Independence	Interdependent

Independence within/regardless of team involvement

- Provided a ***definition of independence*** in the context of collaborative work (e.g., ***as primary decision maker for his or her portion of a program of research*** (Indiana U MS 2016)).
- Suggested faculty to ***seek ways to establish independence*** particularly when collaborative with senior colleagues (U Illinois Chicago CA 2016).
- Stated dossier must include evidence or ***document contributions to collaborative research that indicated a faculty members independence*** (U of Michigan CA, 2016; U of Minnesota MS, 2016).
- Included language that was ***contradictory*** in nature by stating " it is vital to establish the **autonomous role** *played* by the candidate ***in collaborative*** publications and grant proposals." (Indiana U CA 2016)

Aligning Our Context

Our scientific enterprise is largely misaligned with the critical need we for working in diverse teams in order to solve our scientific and societal challenges.

- Education
- Training
- Rewards & Recognition
- Academic structures
- Publication venues
- Team Functioning
- Strategic Planning
- Funding
- Grant Review

There are boundless opportunities from where each of us sit to influence our culture

Closing: Opportunities

1. Support the identification, adaptation, and use of **tools and resources**
   - e.g., Collaboration Plans, on-boarding letters, conflict prevention strategies
2. Consider elements of **Collaboration Plan** that your university can bolster
   - e.g., policies that support team science, collaborative technologies
3. Address need for personnel (faculty/staff/students) with **team science competencies**
   - e.g., more stable support for advanced project management staff, faculty training
4. Support **Development Phase** work
   - e.g., ideas labs, strategic use of pilot funds
5. Identify ways to support/recognize the value of **setting and maintaining strategic visions**
   - e.g., at all levels, external/internal advisory boards, incentives at the department level
6. Align **Promotion and Tenure** policies with team science
   - e.g., addressing incremental steps, considerations of paradigm shifts

Team Science Resources

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