Supporting Individuals and Enhancing Teams

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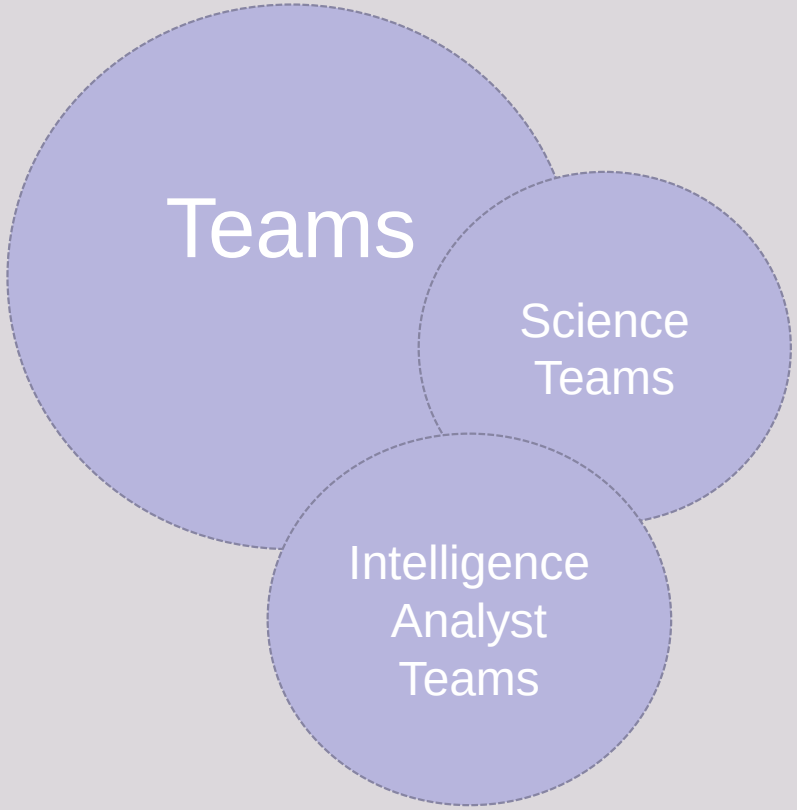
The Science of Team Science is a cross-disciplinary field of study that aims to: **(1) *generate an evidence-base* and (2) *develop translational applications* to help maximize the efficiency, effectiveness of team science**

- **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?**



- What can we learn from studies across all types of teams?
- How are science teams unique from other teams and similar to IA teams?
- What are the transportable considerations from teams to IA teams?
- What are the implications for supporting IA work?

Academic Teams, Intelligence Analyst Teams

Similarities

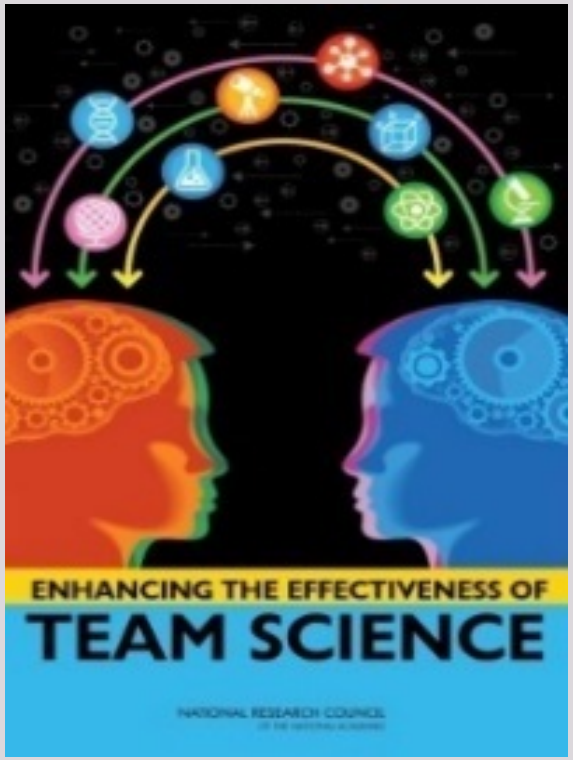
- Knowledge/intellectual work
- Products
  - Publications, reports, briefs
  - Presentations, briefings
  - Advisory meetings, expert input

Distinctions

- Academic researchers
  - Researchers as “free agents”
  - Tenure and promotion process
- Intelligence analysts
  - Leadership history and culture (e.g., leaders from branches of military)
  - Power dynamics (e.g., clearance classification levels)

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

National Research Council. (2015). Enhancing the effectiveness of team science.

A 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

Across

Disciplines

Within

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

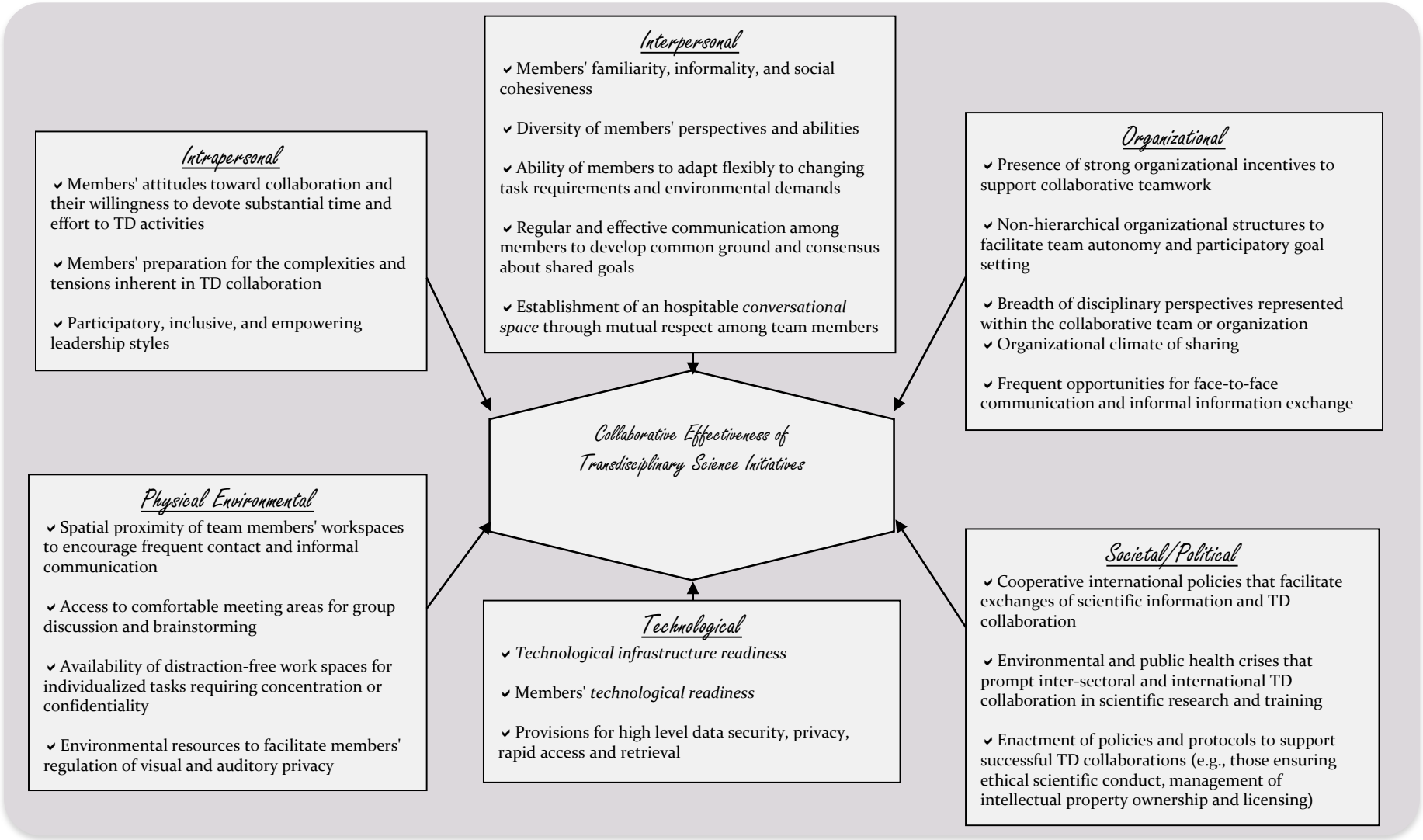
Unidisciplinary

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

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.

Findings from the Science of Team Science (SciTS)

EXAMPLES

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

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

Barjak & Robinson, 2008; Freeman & Huang, 2015; Sud & Thelwall, 2016; Jones, B., Wuchty, S., & Uzzi, B., 2008; Barjak & Robinson, 2008; Hsiehchen, Espinoza, & Hsieh, 2016

Disciplinary Diversity

Greater productivity, Innovation, Reach

- **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

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

Hall et al., 2012; Stvilia et al., 2011; Cummings, 2005; Lee, Walsh, & Wang, 2015; Lungeanu et al., 2014; Misra, Stokols, & Cheng, 2015; Larivière, Gingras, Sugimoto, & Tsou, 2015; Hall, Stokols, Stipelman, et al.,2012; Vogel, Stipelman, Hall et al., 2014;Stipelman, Hall, Zoss, et al., 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

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

Wu, Wang & Evans, 2017; Winnek et al., 2016; Onal Vural et al., 2013; Guimera, et al., 2005

Cultural & Ethnic Diversity

Enhances Outcomes

- Papers published by authors from **different ethnic backgrounds** received **more citations** and were more likely to be published in journals with **higher impact factors**

- In **International collaboration** in European life scientists, cultural diversity among junior scientists has a **curvilinear** relationship on team **productivity** (i.e., # of publications).

- Teams with **moderate levels of diversity among Ph.D. students** were more productive than those with very high, or no diversity (there was no impact of postdoctoral cultural diversity).

Cultural/Ethnic diversity enhances outcomes.

Moderate levels of diversity appear to be better than no diversity or very high levels diversity.

Freeman RB, Huang W., 2015, Barjak F, Robinson S., 2008; Dahlander & McFarland, 2013; Lungeanu & Contractor, 2015; S Misra et al., 2015; Stvilia et al., 2011; Sud & Thelwall, 2016

Gender Diversity

Collaborative tendencies

- Women are more likely to **collaborate outside their discipline**.

Collaborative success

- **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.**

Rational for collaboration

- Males - # of collaborators = **instrumental** (e.g., reputation, complementary skills /knowledge) and **experience reasons** (e.g., know the collaborator for a long time)
- Both male and female scientists collaborate because of **mentoring reasons** such as helping graduate students

Women collaborate more than men, particularly ID.

Gender diversity leads to better outcomes.

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**

Coordination, Coordination, Coordination

Enhances success

- The projects that used **more coordination mechanisms** had **more successful outcomes**
- Yet, 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** such as 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.***

The use of coordination mechanisms is critical for success.

The number of coordination mechanisms should increase as the complexity of the project increases.

Vogel, Hall et al., 2014; Walsh & Lee, 2015; Cummings & Kiesler, 2005, 2007

The power of measurement

- Outcomes, outputs, performance (e.g., bibliometrics)
  - Implications for research outcomes (enhanced outcomes for complex teams)
  - Implications for team behavior (we get what we measure, and what remains hidden)
  - Individual vs team measurement
  - Bias – success, relative failure
- Mediators and moderators
  - Influence on variability of findings
- Performance
  - Review, tenure and promotion

Key principles, concepts, typologies

Heuristic of the Critical Considerations of Teamwork

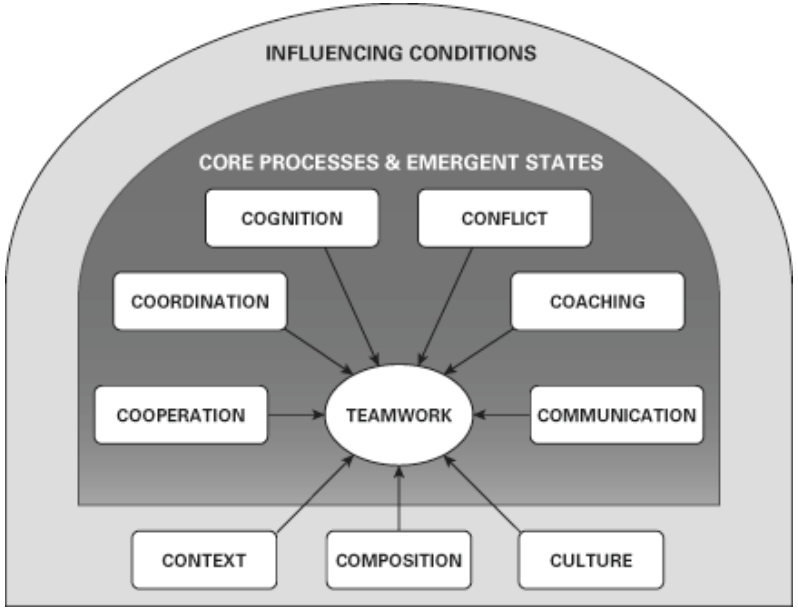
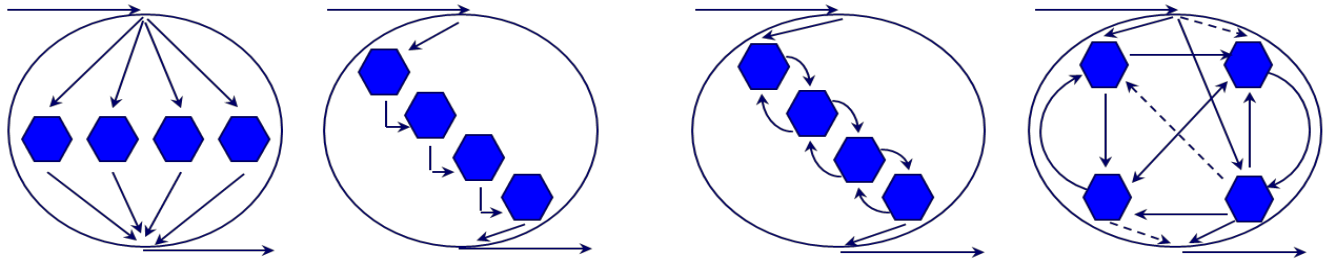


Figure 3. Characteristics of Simple vs. Complex Team Workflows.

Task Environment:	• Static	• Dynamic
External Coupling:	• Loosely Coupled	• Tightly Coupled
Internal Coupling:	• Asynchronous • Weak Linkages	• Synchronous • Strong Linkages

Workflow Interdependence:



• Pooled • Sequential • Reciprocal • Intensive

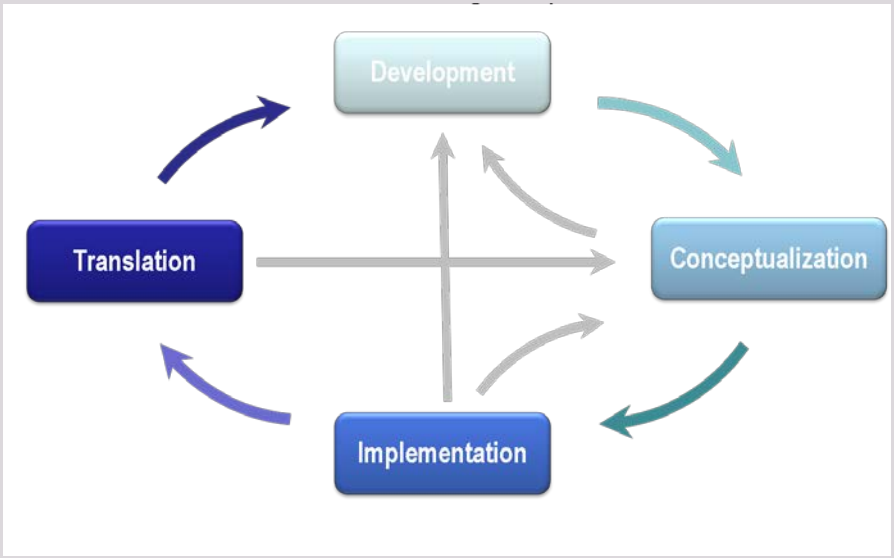
Simple — **Team Task Complexity** — Complex

From: Bell, B. S., & Kozlowski, S. W. J. (2002). Virtual teams: Implications for leadership. *Group and Organization Management, 27*, 12-49.

Human Resource Management Volume 54, Issue 4, pages 599-622, 29 OCT 2014 DOI: 10.1002/hrm.21628
http://onlinelibrary.wiley.com/doi/10.1002/hrm.21628/full#hrm21628-fig-0001

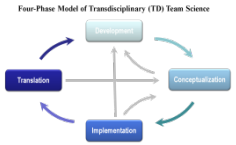
Contextualizing Team Principles

Four Phase Model of Transdisciplinary Research



Heuristic for key processes and team types applied to intellectual work of science teams.

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, 415-430.



Development Phase:

Goals & Key Processes

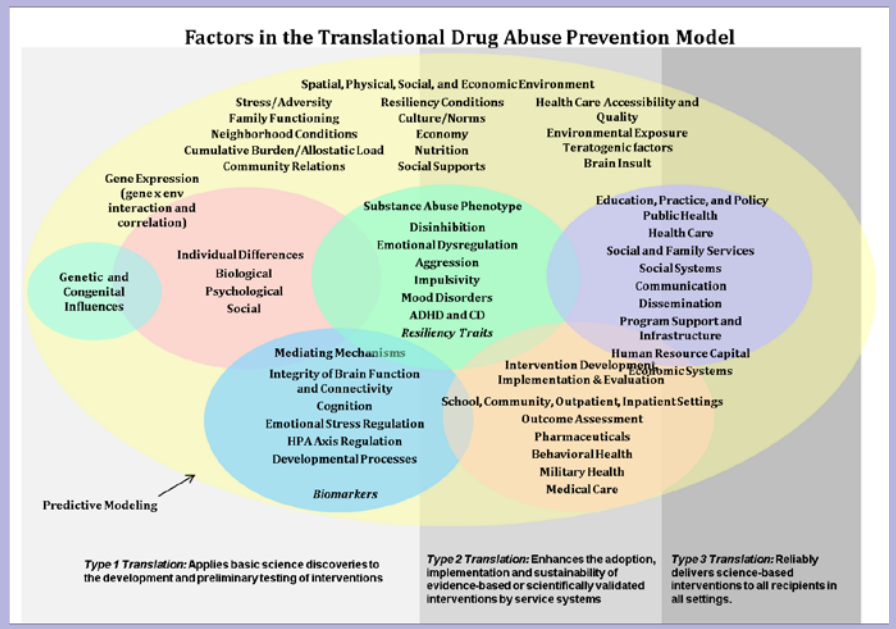
Goal: Define the scientific or societal **problem space** of interest, including identifying the intricacies & interconnections of concepts that fall within the problem space & establishing the boundaries of the problem space to be addressed

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:

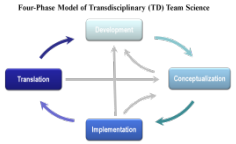
- Network, working group, advisory group, emerging team



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

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, 415-430.



Conceptualization Phase:

Goals & Key Processes

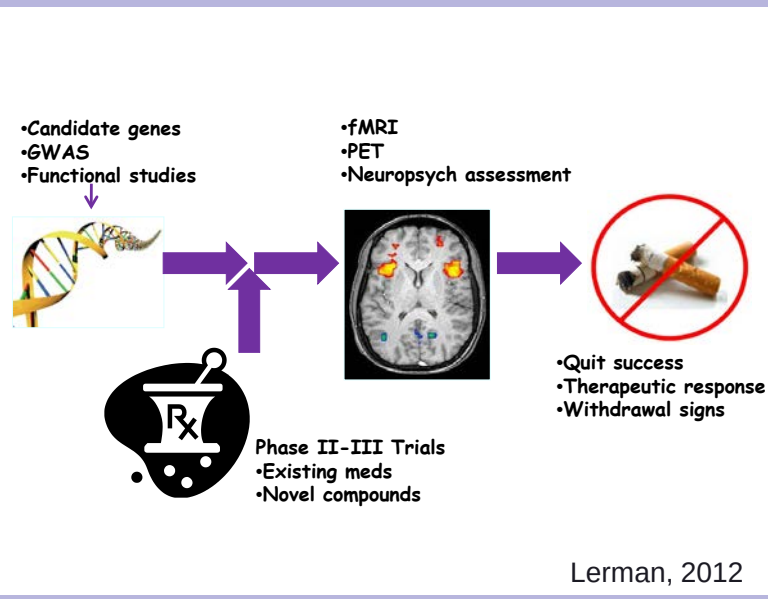
Goal: Develop novel research questions, hypotheses, & a conceptual framework & research design that integrate collaborators' disciplinary perspectives & knowledge domains to address the target problem in innovative ways.

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

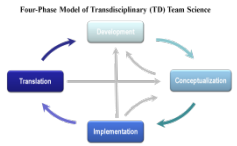
Team Type:

- Emerging team, evolving team



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

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, 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

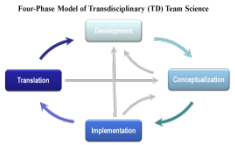
"Real" vs "Pseudo" team

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 & Lyubovnikova, 2012

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).



Translation Phase:

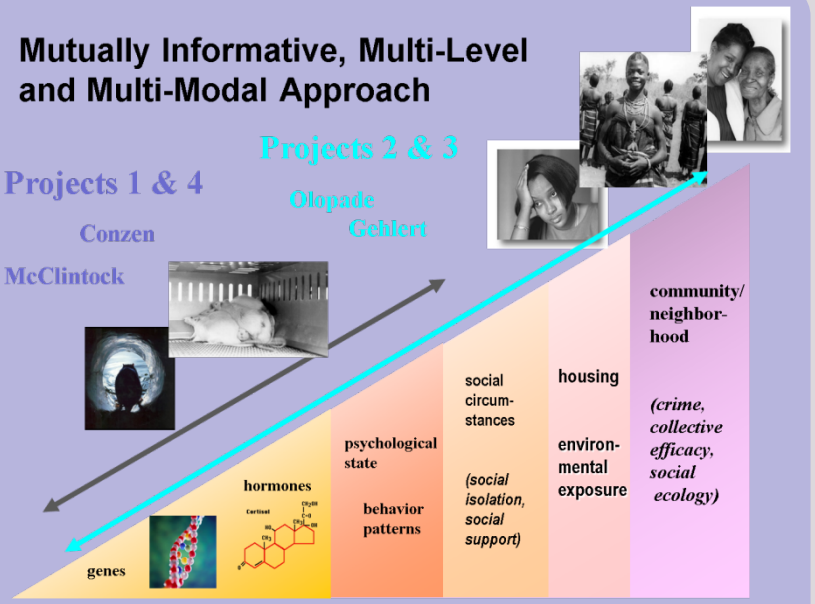
Goals & Key Processes

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



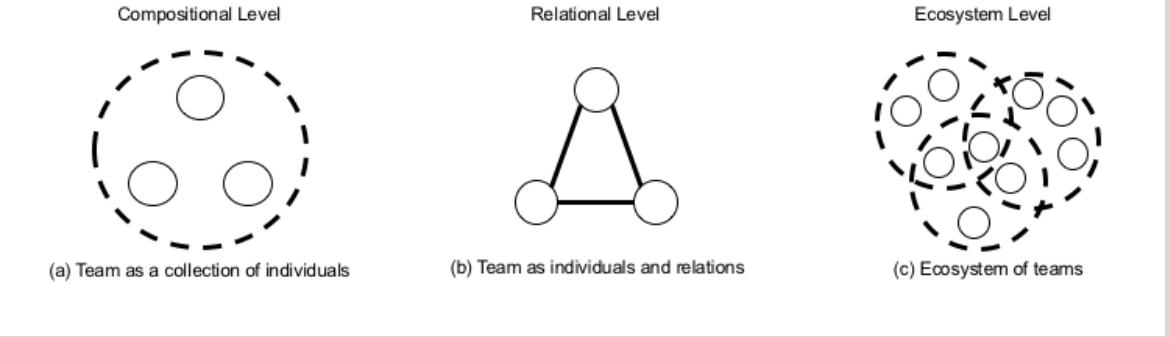
Initiate community outreach activities to identify translational partners to evolve the TD team. Work together to identify & implement translational goals in ways that draw upon the expertise of both investigators & translational partners

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).

Contextual Considerations for IA:
Ted's Case Example: Developing an IC Publication

- What types of "teams" are involved in what part of the process?
- What are the typical sets of actions required to complete IA work?
- What are the patterns of engagement required to develop the key products?
- What key processes are critical to the various types of collaboration?

The President's Daily Brief



Building teams and Fostering Collaboration

- Selection vs acquisition of skills – what is needed when?
- Training vs guidance - upfront and on-going
- Supervisory vs technological augmented
- Individual review vs panel/committee
- Culture of collaboration
- Knowledge hierarchies
- Leadership - all analysts are leaders and need leadership skills (within hierarchical or heterarchical)

Enhancing contextualized understanding

- Robust research on teams over the 50+ years:
  - In the “lab” vs in “the wild”
  - Parsimony vs complexity
  - Production/Action vs Intellectual work

Meta-analysis of team training:

- 1660 student teams
- 762 military teams
- <10 each from medical, aviation, business settings.

Methodological Opportunities

- Emphasis on content
- Natural experiments
- Quasi-experimental designs
- Computational modeling

(Salas et al., 2008)

Leveraging the system

- Adaptive, learning system – individual, team , organization
  - Technology and trace data (collaborative platforms, people analytics)
  - Systems that use technological inputs to give real-time feedback/guidance to individuals and teams
  - Systems that monitor patterns of engagement and collaboration to assess collaborative success
  - Online or accessible training opportunities that augments/supports autonomous learning
    - To help open the black box (leaders and analysts)

Examples Of Training For Competencies By Key Team Science Dimension

Dimension	Skills/Processes	Type of Training
Diversity	Communication and interpersonal interactions	ID educational seminars, interpersonal skills training
Integration	Coordination and communication, shared mental models	Cross-training, knowledge-sharing training, coordination training
Size	Compositional, Taskwork, and Teamwork Transactive Memory	Positional clarification, communication, coordination training
Proximity	Compilational, compositional transactive memory, team cohesion/self-efficacy	Team reflexivity training, positional clarification training
Goal alignment	Shared vision/goals, communication	Visioning/goal-setting exercises, Team reflexivity training, problem/team-based learning
Boundaries	Team-specific knowledge/goals	Cross-training, knowledge-development
Task interdependence	Taskwork transactive memory	Team reflexivity training

Adapted from the NRC (2015) Enhancing the Effectiveness of Team Science

Knowledge pluralism and depth

- **Societal and global perspectives**
  - belief that complex problems should be approached from a broad, multi-level perspective
- **Understand others disciplines**
  - understand core theories, and methods from other disciplines
- **Methodology**
  - take a methodologically pluralistic approach
- **Disciplinary grounding**
  - cultivate deep knowledge within one or more disciplines

Intrapersonal Competencies

- Demonstrate **broad intellectual curiosity** to ask questions across disciplines
- Maintain an **open mind** in order to clearly hear perspectives of others during explorative interdisciplinary dialogues
- Recognize **personal strengths and weaknesses** as related to interdisciplinary 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 in interdisciplinary collaborations

Adapted from Holt, 2013; NRC 2015; Gebbie et al., 2008

Disciplinary Awareness and 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 interdisciplinary 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 an interdisciplinary team

Adapted from Holt, 2013; NRC 2015; Gebbie et al., 2008

Processes of Integration

- Collaborate with others to **integrate theories, methods and insights** of multiple disciplines **to improve understanding of problem** or issue
- Develop **interdisciplinary research framework(s**) in collaboration with scholars from other disciplines
- Develop a **shared interdisciplinary vision** with collaborators, communicate it effectively, and revisit it at regular intervals to determine if changes are required
- **Modify own work or research agenda** as a result of interactions with colleagues from fields other than own
- **Integrate concepts** and methods from multiple disciplines **in designing research protocols**

Adapted from Holt, 2013; NRC 2015; Gebbie et al., 2008

Teamwork, Management, Leadership

- Build **trust** among collaborators in an interdisciplinary team
- Understand strategies for interdisciplinary **teamwork and communication** including clarifying the meanings of key concepts and appreciating the perspectives of other disciplines
- Develop **team skills** in order to strengthen team structure and dynamics
- Build skills for **team facilitation and leadership**
- Understand and effectively **manage conflict, feedback and credit** relative to interdisciplinary team research
- Contribute to the creation of c**ollective interdisciplinary knowledge** that includes: thinking with team, adapting individual contributions, trusting value of other contributors, and negotiating differences

Adapted from Holt, 2013; NRC 2015; Gebbie et al., 2008

Competencies of Fruition

- **Contribute to** a variety of **educational initiatives** with scholars from other disciplines, e.g. seminars, conferences, scholarly presentations, and research symposia
- **Present interdisciplinary research** at venues representing more than one discipline
- **Disseminate interdisciplinary research results** to various audiences in multiple disciplines
- **Draft research proposals and author publications** in partnership with scholars from other disciplines

Adapted from Holt, 2013

For More Information

- **Kara L. Hall**, PhD
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- **Team Science Toolkit**
  - www.teamsciencetoolkit.cancer.gov

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