Introduction to the Science of Team Science

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INSciTS Building the knowledge base for effective team science
International Network for the Science of Team Science

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Outline

- Collaboration challenges
- Team Science definitions
- Evidence for impact of team science
- How you can develop team science skills

- **Collaboration challenges**
- Team Science definitions
- Evidence for impact of team science
- How you can develop team science skills

How many of YOU …

- are part of a research team?
- do interdisciplinary research?
- do multidisciplinary research?
- do transdisciplinary research?
- knew there was a difference among those terms?
- have experienced a good collaboration?
- have experienced a bad collaboration?

Team Science = Collaboration?

- Yes, but …
  - It is more
  - Collaboration is influencing the practice of science
  - Cross-disciplinary collaboration is influencing production of knowledge

Published in *Science*

Identify two challenges

"The interdisciplinary approach is becoming one of the prominent characteristics of [science] and represents a synthesizing trend which focuses the specialized research techniques on problems common to a number of separate disciplines.

Such cooperative research has to overcome serious obstacles when operating within the existing departmentalized framework of the universities. It appears that real progress in this direction will be made in institutions which are organized on a permanent and frankly cooperative basis.

Psychologically, interdisciplinary research requires not only abstract, theoretical intelligence…, but also 'social intelligence.' Cooperative work is a social art and has to be practiced with patience."

Collaboration Challenges

- Problems of Infrastructure - Tangible and Tacit
  - Inherent challenge associated with structure of the modern university, *i.e.*, the discipline-bound department
  - Tacit norms that hinder interaction
  - Reward structures that focus on individual effort
- Problems of Interaction
  - Difficulty inherent in communicating and collaborating across disciplines
  - Patience and social intelligence are necessary precursors to effective collaboration in such environments

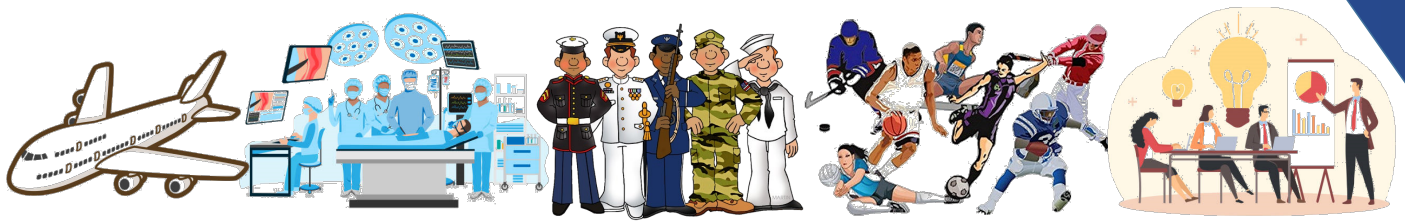
Why was that quote informative?

- Anyone involved in collaboration has probably experienced both challenges
- What is informative is not just what was said, but when it was said
  - One of first articles specifically addressing interdisciplinary research (Brozek & Keys, 1944)
- Science still struggles, can we overcome these challenges?

Can we overcome the challenges? YES!

- Increased emphasis on collaborative research that creates teams of scientists to address complex phenomena
  - Funders (*e.g.*, NIH) are specifically encouraging and supporting collaborative research projects
- Academia, Industry & Policy communities all making more of a concerted effort to study scientific collaboration

- Tremendous growth in the study and understanding of groups and teams



- Scientific study of teamwork can be a true catalyst for change
  - Matured into its own area of inquiry producing a rich base of knowledge
  - Helps us to better understand complex coordination used by teams

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Can we overcome the challenges? YES!

?

- Collaboration challenges
- **Team Science definitions**
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Definitions

- What is a “team”?
- Groups *vs*. teams
- Disciplinary, multidisciplinary, interdisciplinary, transdisciplinary, cross-disciplinary

Definitions

Teams	**two or more people working interdependently (collaborating) towards a shared common goal or task**
Team-Building	**process of gathering the "right" people & getting them to work together to accomplish a goal/task**
Team Leadership	**guiding a group of individuals to work as a unit to accomplish a goal/task**

Group *vs.* Team

Groups

Group *vs.* Team

Teams

Group *vs.* Team

	Groups	Teams
Members	Independent	Interdependent
Goals	Individual	Shared
Identity	Individual (me)	Shared (we)
Leadership	Often single	May be shared
Products	Individual	Collective
Reward	Individual	Collective
Cohesion	None/limited	Esprit de corps
Conflict	Reactive	Expected/proactive


Unidisciplinary?
Multidisciplinary?
Interdisciplinary?
Cross-disciplinary?
Transdisciplinary?
TEAM

Collaboration Across Disciplines: Some More Definitions

- Unidisciplinary

Cross-Disciplinary

- Multidisciplinary
  additive, complementary, independent, sequential
- Interdisciplinary
  interactive, combine, integrate

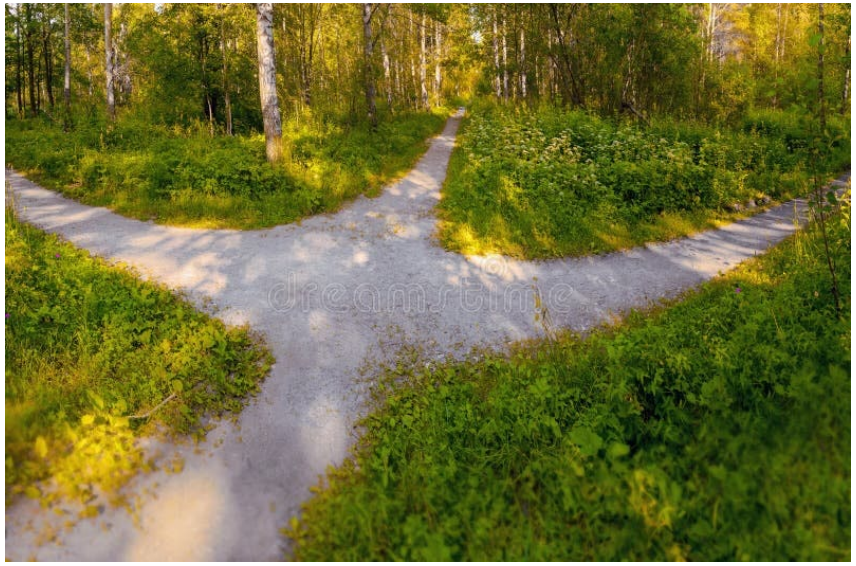
- Transdisciplinary
  holistic, transcend disciplinary perspectives, new methodologic or conceptual frameworks

Team Science > Collaboration

Low **Level of Interaction and Integration** ***High***

Investigator-initiated research

- Investigator works on a scientific problem with own research team



Research Collaboration

- Group works on a scientific problem, each bringing some expertise to the problem
- Each member works on a separate part, which are integrated at the end
- The interaction of the lead investigators varies from limited to frequent with regard to data sharing or brainstorming

Integrated Research Team

- Team works on a research problem with each member bringing specific expertise to the table
- There are regular meetings and discussions of the team's overall goals, objectives of the individuals on the team, data sharing, and next steps
- One person takes the lead while other members have key leadership roles in achieving the goal

Adapted from "Team Science: Building Successful Research Collaborations" by L. Michelle Bennett, PhD, Deputy Scientific Director, NHLBI, NIH and Howard Gadlin, PhD, Ombudsman, OD, NIH. PPT presented at University of Iowa, January 2013

- Collaboration challenges
- Team Science definitions
- **Evidence for impact of team science**
- How you can develop team science skills

Is there evidence for impact of team science?

The Increasing Dominance of Teams in Production of Knowledge

Stefan Wuchty,[1]* Benjamin F. Jones,[2]* Brian Uzzi[1,2]*†

We have used 19.9 million papers over 5 decades and 2.1 million patents to demonstrate that teams increasingly dominate solo authors in the production of knowledge. Research is increasingly done in teams across nearly all fields. Teams typically produce more frequently cited research than individuals do, and this advantage has been increasing over time. Teams now also produce the exceptionally high-impact research, even where that distinction was once the domain of solo authors. These results are detailed for sciences and engineering, social sciences, arts and humanities, and patents, suggesting that the process of knowledge creation has fundamentally changed.

18 MAY 2007 VOL 316 **SCIENCE** www.sciencemag.org

How has team size grown?

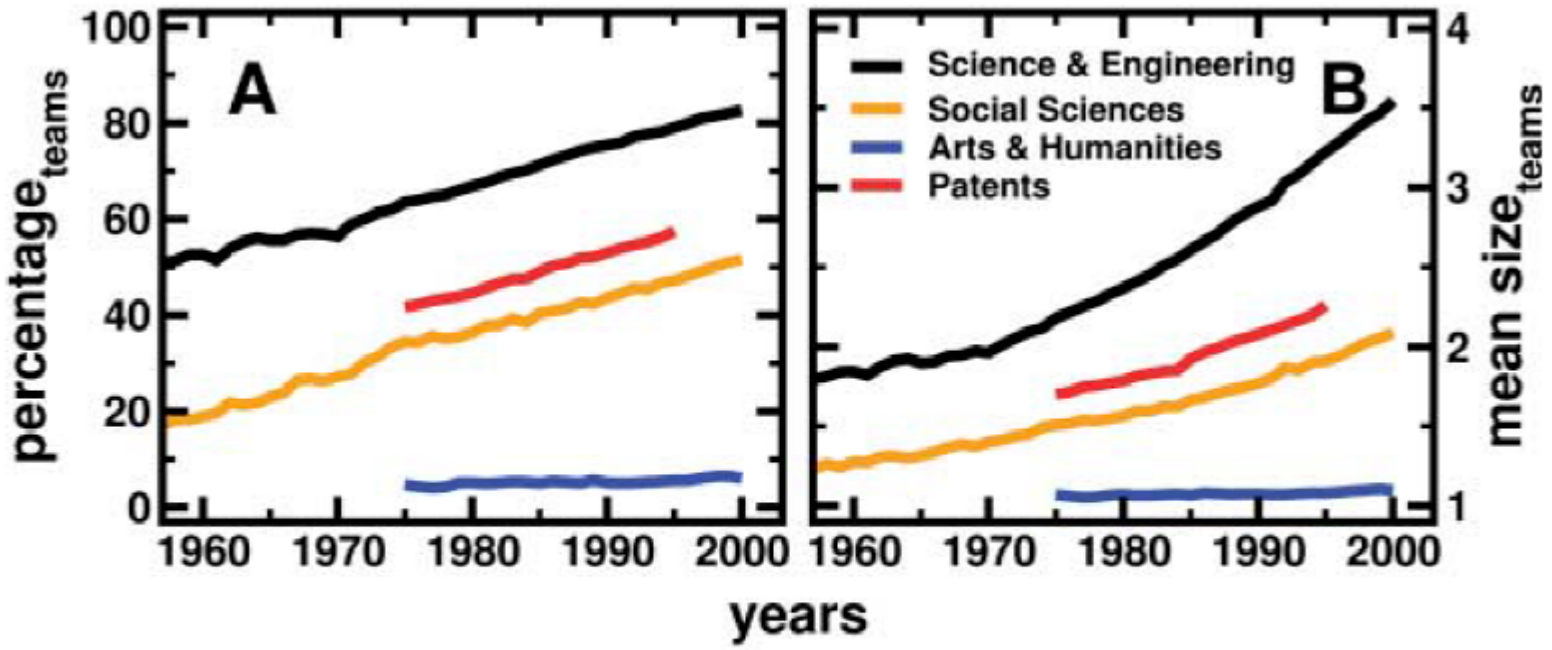


Fig. 1. The growth of teams. These plots present changes over time in the fraction of papers and patents written in teams (**A**) and in mean team size (**B**). Each line represents the arithmetic average taken over all subfields in each year.

Is the shift to teamwork seen in all fields?

Table 1. Patterns by subfield. For the three broad ISI categories and for patents, we counted the number (*N*) and percentage (%) of subfields that show (i) larger team sizes in the last 5 years compared to the first 5 years and (ii) RTI measures larger than 1 in the last 5 years. We show RTI measures both with and without self-citations removed in calculating the citations received. Dash entries indicate data not applicable.

		Increasing team size		RTI > 1 (with self-citations)		RTI > 1 (no self-citations)	
	N_{fields}	N_{fields}	%	N_{fields}	%	N_{fields}	%
Science and engineering	171	170	99.4	167	97.7	159	92.4
Social sciences	54	54	100.0	54	100.0	51	94.4
Arts and humanities	27	24	88.9	23	85.2	18	66.7
Patents	36	36	100.0	32	88.9	–	–

$$\text{RTI, relative team impact} = \frac{\text{mean \# citations team-authored}}{\text{mean \# citations solo-authored}}$$

How is team size related to impact?

Relative Team Impact (RTI)

$$\text{RTI} = \frac{\text{mean \# citations team-authored}}{\text{mean \# citations solo-authored}}$$

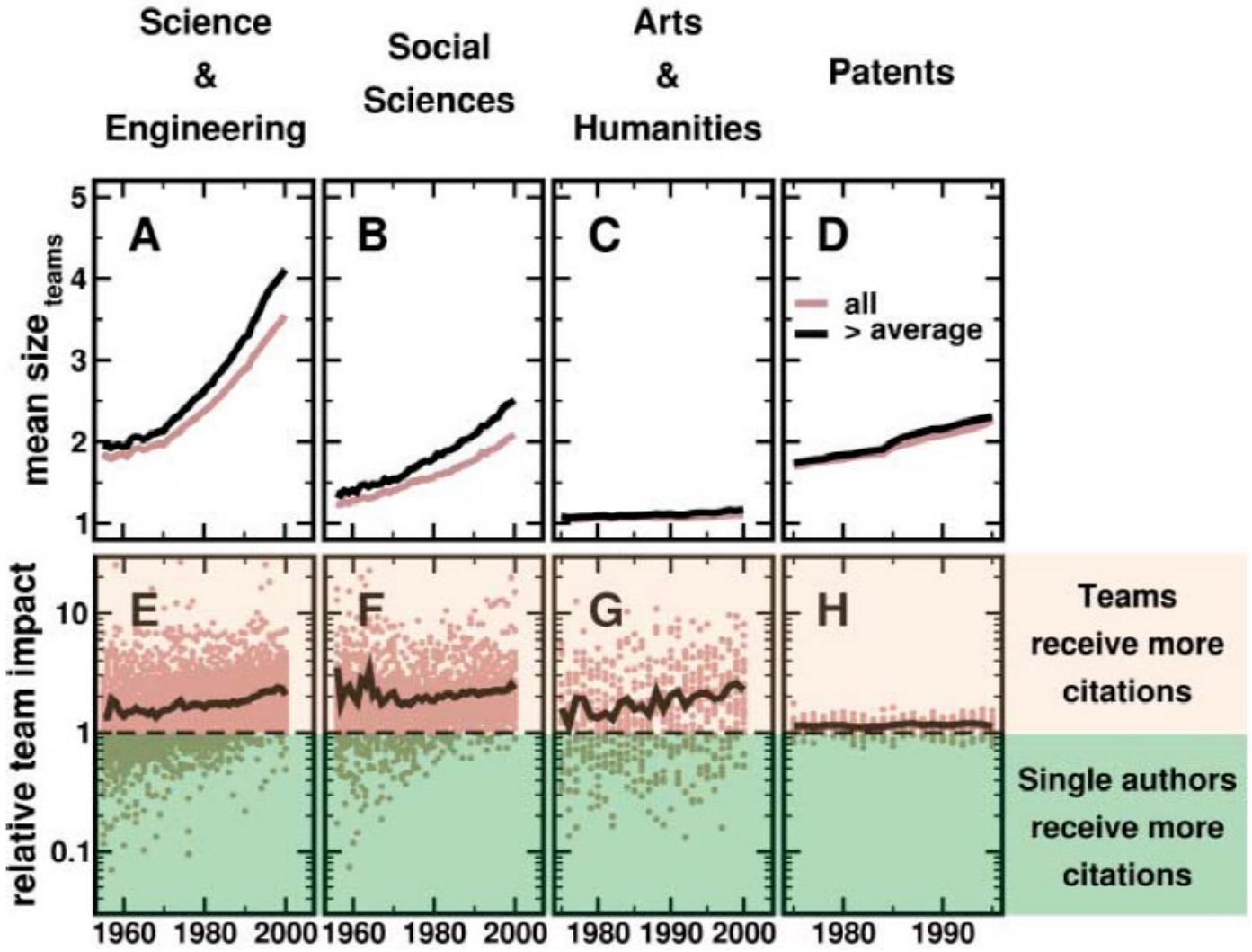


Fig. 2. The relative impact of teams. (**A** to **D**) Mean team size comparing all papers and patents with those that received more citations than average in the relevant subfield. (**E** to **H**) The RTI, which is the mean number of citations received by team-authored work divided by the mean number of citations received by solo-authored work. A ratio of 1 indicates that team- and solo-authored work have equivalent impact on average. Each point represents the RTI for a given subfield and year, whereas the black lines present the arithmetic average in a given year.

- Collaboration challenges
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How can we USE team science?

- Recognize scientific problems that would best be answered using a team science approach
- Interdisciplinary and transdisciplinary research require action
  - connecting or interacting among disciplines
- Not just any activity, but team activity: a process engaged by members of a coordinated scientific team
  - two or more people working interdependently (collaborating) towards a shared common goal or task

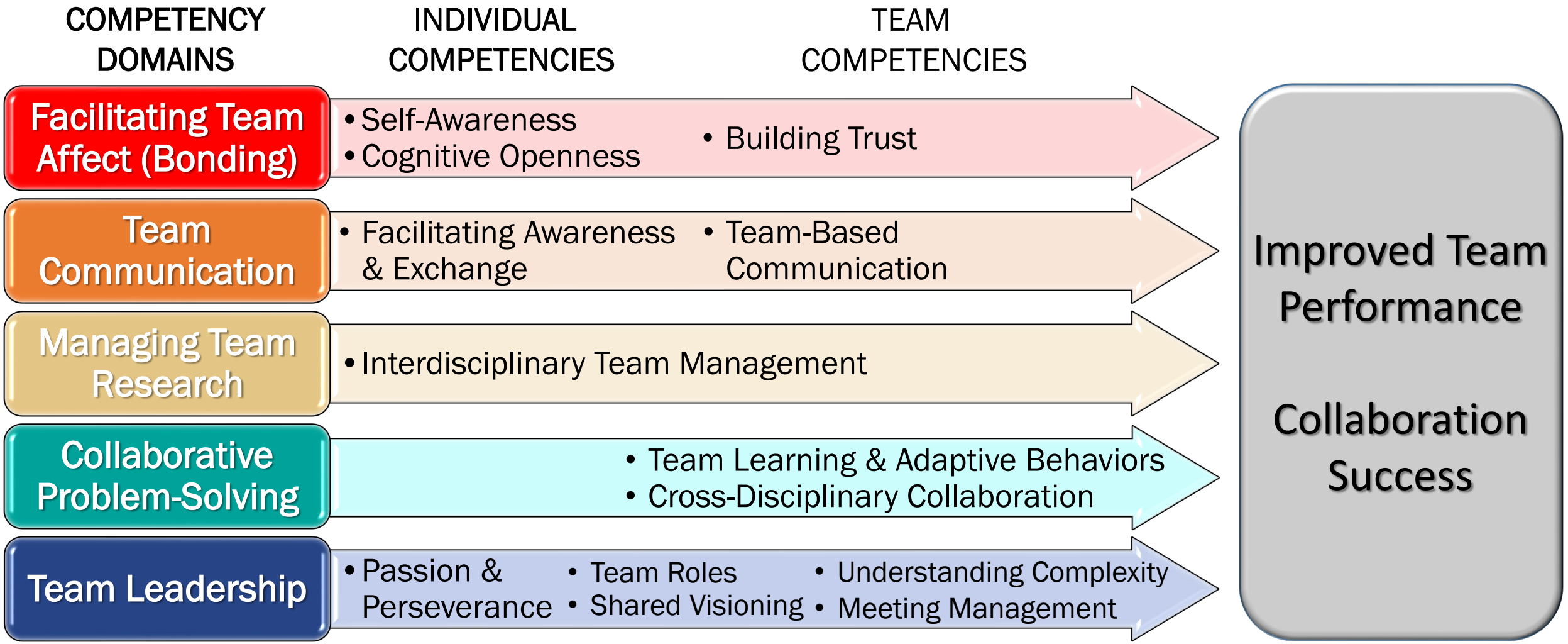
How can we USE team science?

- Use the Science of Team Science
  - Understand and improve how scientists interact and integrate across disciplinary, professional, and institutional boundaries

  - What knowledge, skills, and attitudes are important?

Team Science Competencies

Lotrecchiano *et al.*, 2020



Team Science Skill Development

Human Nature

- Personality Traits (e.g., Myers-Briggs)
- Behavior Traits (e.g., DISC)
- Emotional Intelligence (e.g., EQi)

Communication Skills

- Listening Skills
- Constructive Feedback
- Conflict Management

Team Science Tools

- Team Design & Diversity
- Goal Setting
- Collaboration Plans
- Authorship Agreements
- Task & Support Behaviors

Collaborative Problem-Solving

- Collaboration Experience
  - within your team
  - within your discipline
  - with other disciplines

Leadership Skills

- Leadership Styles (Kouzes & Posner)
- Stages of Team Performance (Tuckman)
- Situational Leadership (Hersey & Blanchard)

Can the Use of Competencies Support Productive Mentoring?

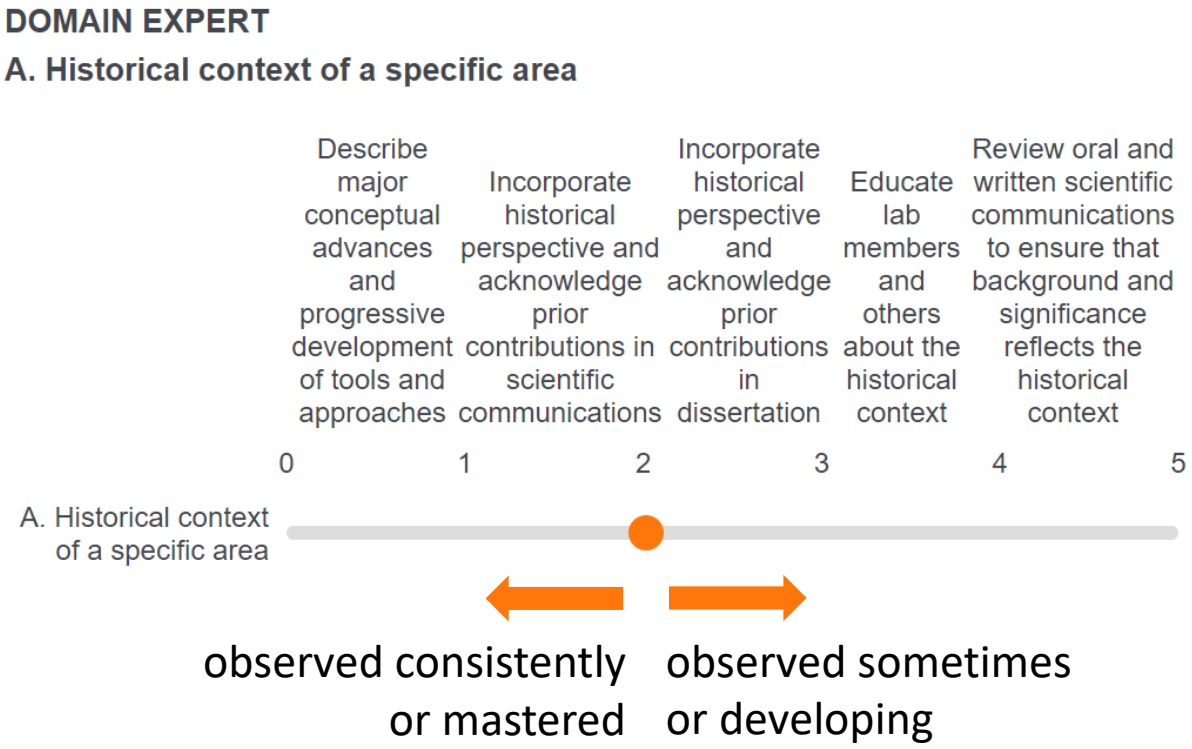
- PROBLEM
  - PhD scientist training has traditionally been an apprenticeship
  - When is a grad student or postdoc ready to finish?
  - “I know it when I see it”
- COMPETENCY
  - The ability to do something successfully or efficiently (Oxford Dictionary)
- GOAL
  - To define required knowledge, skills and attitudes to do something
- A LIST OF COMPETENCIES IS NOT ENOUGH
  - Must be linked to formative assessment

Milestone Approach: Learning Is a Developmental Process

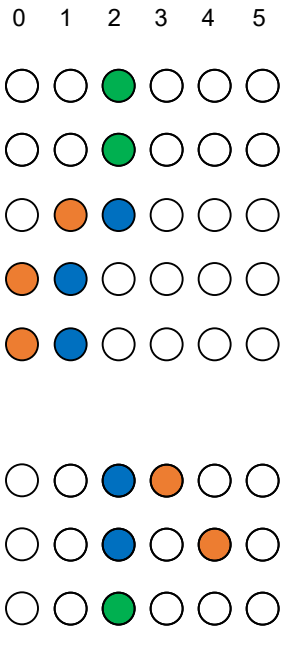
- **Milestones**: expectations for the knowledge, skills and attitudes at stages of development, demonstrated by observable behaviors
  - Verderame *et al.*, 2018. Competency-based assessment for the training of PhD students and early-career scientists. **eLife** 7:e34801

Dreyfus & Dreyfus Levels of Skill Acquisition	**Novice**	**Advanced Beginner**	**Competent**	**Proficient**	**Expert**
	Rule-based behavior, limited, inflexible	Incorporates aspects of the situation	Acts consciously from long-term goals and plans	Sees situation as a whole and acts from personal conviction	Has intuitive understanding of situations, zooms in on central aspects
Translational Scientist Training Stages	**Beginning PhD Student / Clinician beginning research training with little or no experience**	**Advanced PhD Student / Clinician Scientist during early research training**	**Defending PhD Student / Beginning Postdoctoral / Clinician Scientist during later research training**	**Postdoctoral Trainee / Early Career Scientist / Clin Sci near end of research training / Residents/Fellows**	**Science Professional / Research Team Leaders (may be Aspirational)**
Observable Behaviors	**MILESTONES**				
	discuss, describe, follow	identify, use, explain	design, develop, evaluate	plan, adjust, teach	lead, review, mentor

Proposed Process for Mentor & Self-Assessment



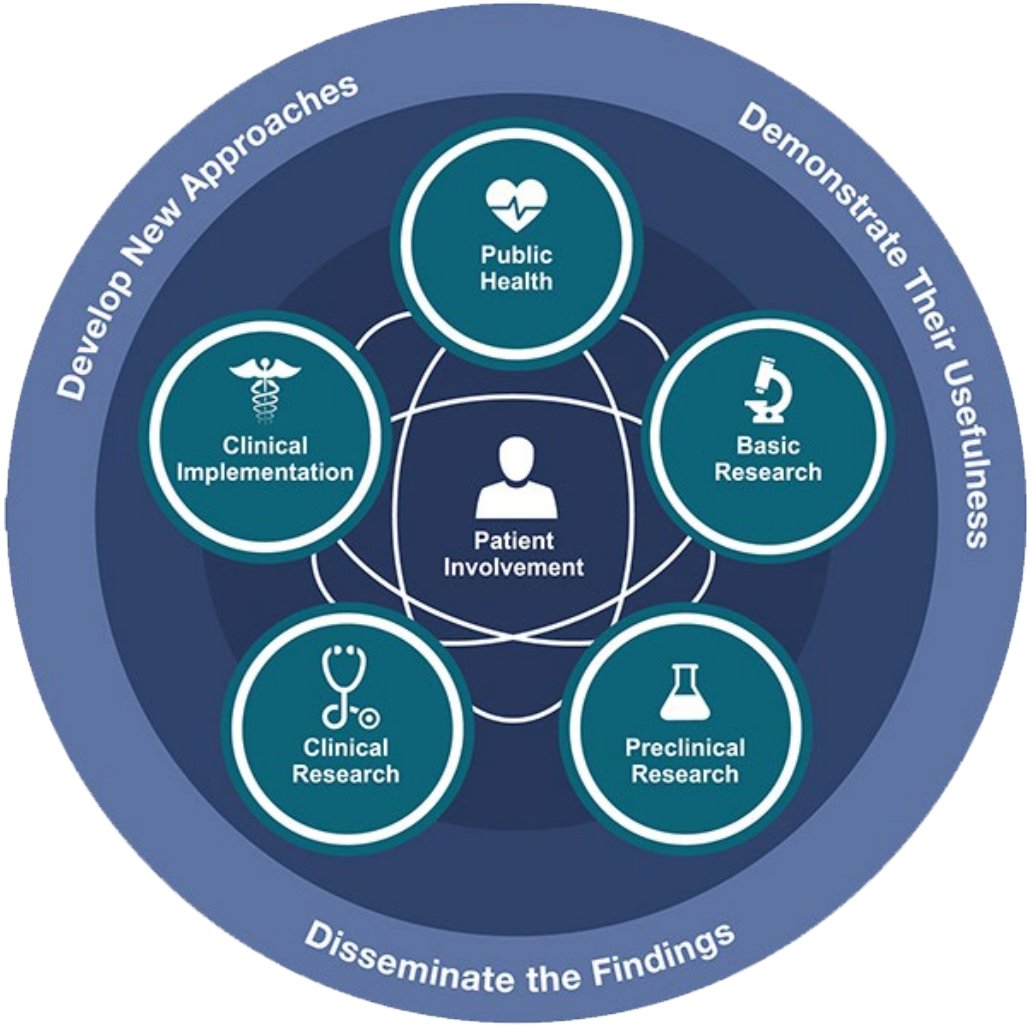
BOUNDARY CROSSER



DOMAIN EXPERT

Trainee Faculty Match

Translational Research & Translational Science



https://ncats.nih.gov/about/about-translational-science/spectrum

Faupel-Badger *et al*., 2022

CTSA Working Group

Translational Science Competency-Based Assessment

Overview

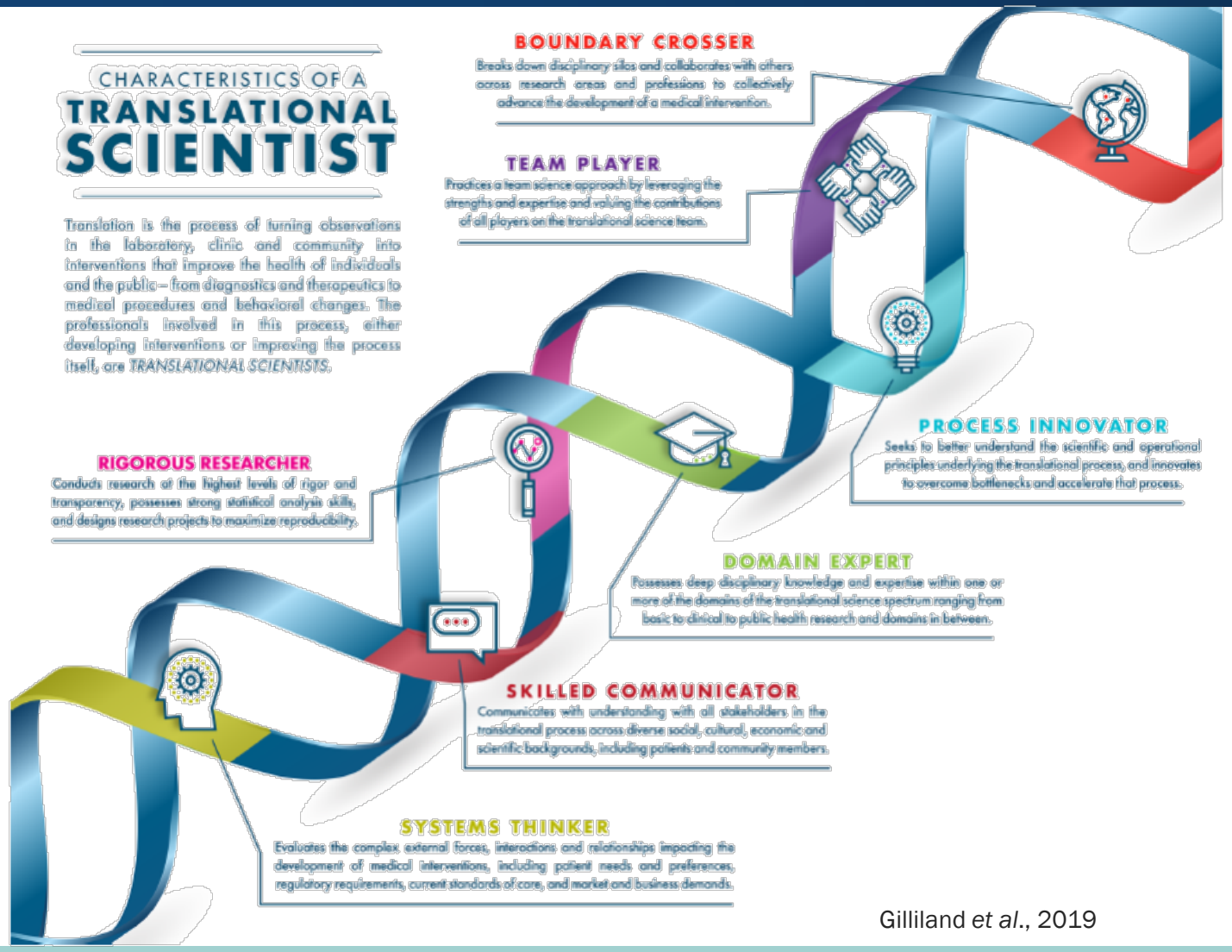
This Working Group aims to identify the most relevant competencies for translational science to develop, pilot test, and implement a competency-based assessment tool for the training of translational scientists. Competency-based assessments (CBA) are utilized in health professions education but are not common in biomedical science graduate education nor in postdoctoral training. The creation and use of a CBA tool will provide trainees with a framework for assessing learning outcomes and optimizing mentored research training experiences.

Log In

Group Goals

- Develop the competency list.
- Calibrate milestones for competency levels.
- Pilot-test the final TS-CBA tool.

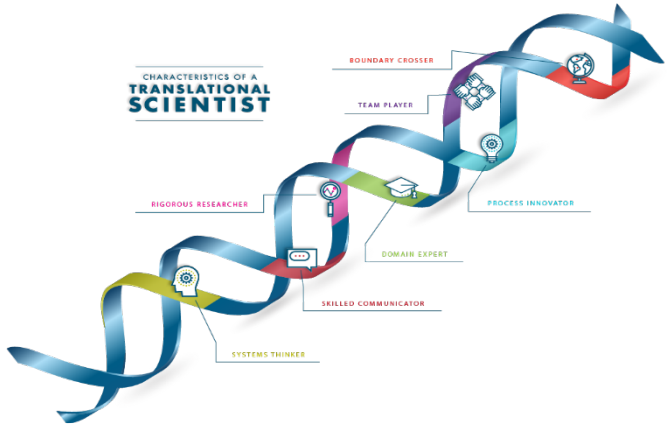
CTSA Competencies



Gilliland *et al.*, 2019

Faupel-Badger *et al.*, 2022

Ten Translational Science Competency Domains



Process Innovator

Systems Thinker

Domain Expert

Boundary Crosser

Team Player

Skilled Communicator

Rigorous Researcher

Ethical Researcher

Resilient Scientist

Research Leader

Point of View: Competency-based assessment for the training of PhD students and early-career scientists

Michael F Verderame ✉, Victoria H Freedman, Lisa M Kozlowski, Wayne T McCormack

46 Translational Science Competencies

BOUNDARY CROSSER

A. Use knowledge from multiple disciplines
B. Use broad scientific approaches
C. Participate across translational phases
D. Engage stakeholders across professions
E. Engage with communities

DOMAIN EXPERT

A. Use historical context of a specific area
B. Use current content expertise in the specific area
C. Use tools and approaches for the specific area

TEAM PLAYER

A. Demonstrate a cross-disciplinary, collaborative mindset
B. Demonstrate reflective awareness in a team environment
C. Apply strategies to work effectively within diverse teams

SKILLED COMMUNICATOR

A. Practice effective oral presentation skills
B. Write and review scientific manuscripts for publication
C. Write and submit research grant proposals
D. Communicate effectively with patients & community members
E. Communicate effectively with funders
F. Communicate effectively with policy-makers

PROCESS INNOVATOR

A. Focus on unmet needs
B. Use creativity & innovation
C. Seek efficiency & speed
D. Find generalizable & impactful solutions

46 Translational Science Competencies

SYSTEMS THINKER

A. Operate within a system of therapeutic innovation
B. Leverage interconnections of translational research
C. Integrate patient perspectives

RIGOROUS RESEARCHER

A. Recognize important questions
B. Design and execute experimental/study protocols
C. Interpret data & troubleshoot technical issues
D. Design & manage a research program
E. Apply basic statistical analysis methods
F. Use appropriate informatics methods
G. Manage research data
H. Conduct research according to lab safety & regulatory policies

ETHICAL RESEARCHER

A. Practice responsible conduct of research (RCR)
B. Apply ethical decision-making in RCR
C. Display moral courage and research integrity

RESILIENT SCIENTIST

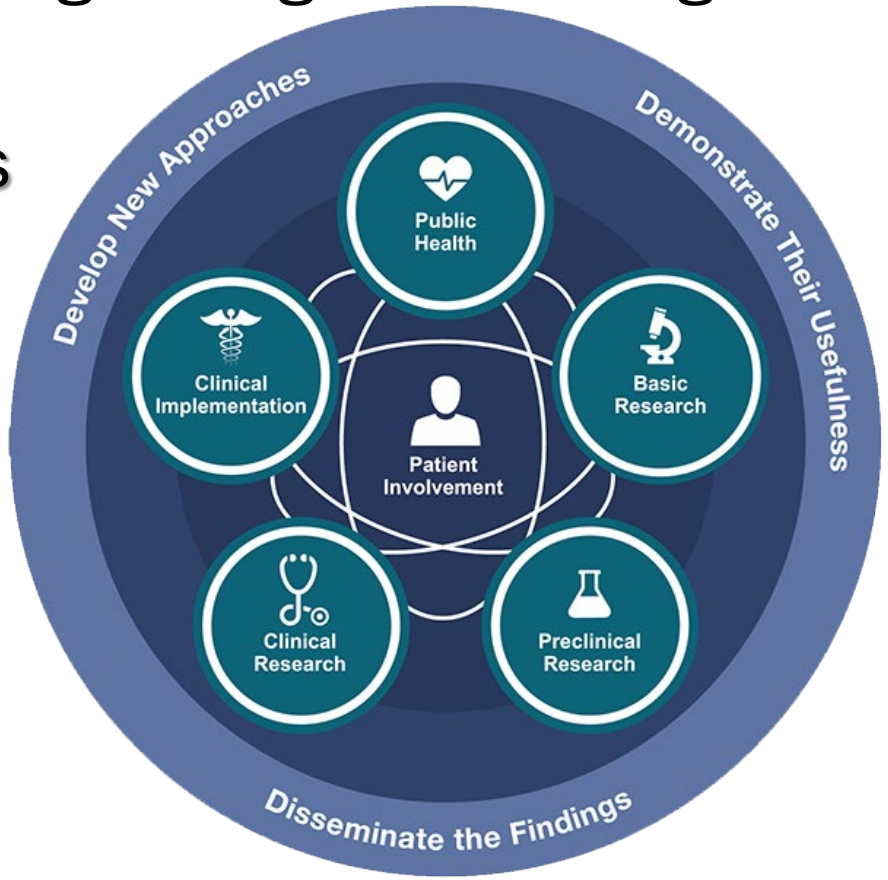
A. Motivate self and others
B. Demonstrate perseverance
C. Adapt to new situations & challenges
D. Seek professional growth opportunities
E. Build professional network

RESEARCH LEADER

A. Develop an inclusive and shared vision
B. Foster integration and a collaborative environment
C. Practices effective organization and planning skills
D. Empower progressive decision making
E. Facilitate collaborative problem-solving
F. Promote a culture of trust and psychological safety

Value of Using a Translational Scientist Competency-Based Mentoring Tool

- Applicants and new Trainees & Scholars informed about expectations
- Tool for self-assessment and self-directed learning throughout training and future research careers
- Tool for mentor assessment of training progress toward acquiring the knowledge, skills and attitudes expected of a translational scientist
- Support productive mentoring conversations
- Combined with curricular mapping and program enhancement plans, provide a framework for continuous improvement of learning objectives, training, and assessment



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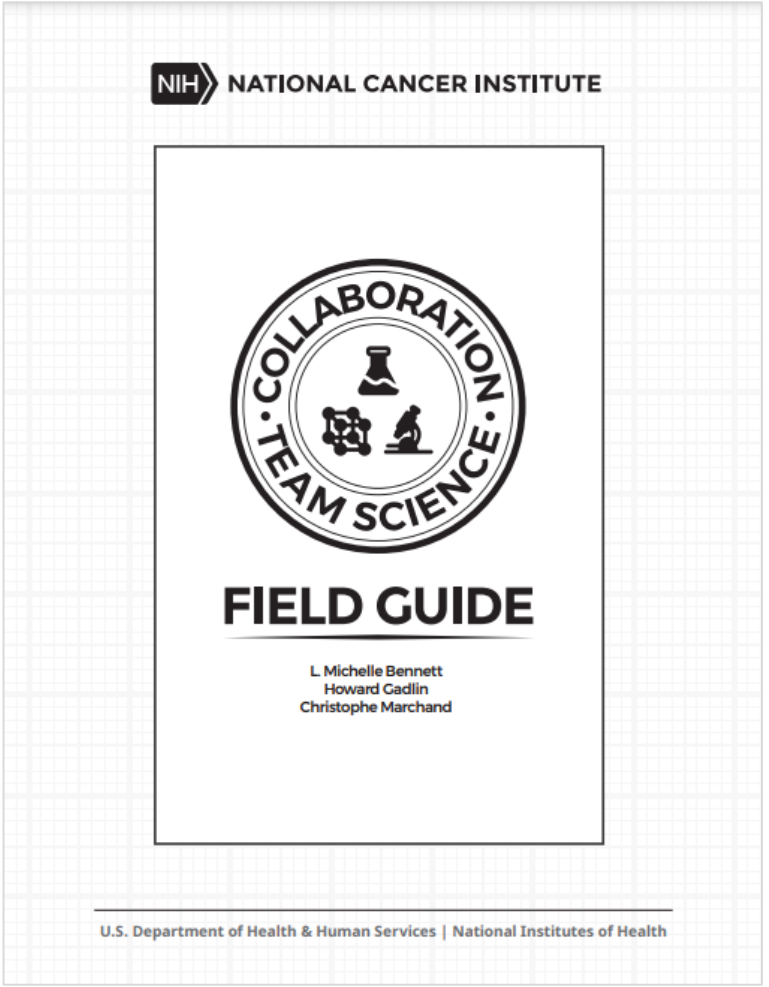
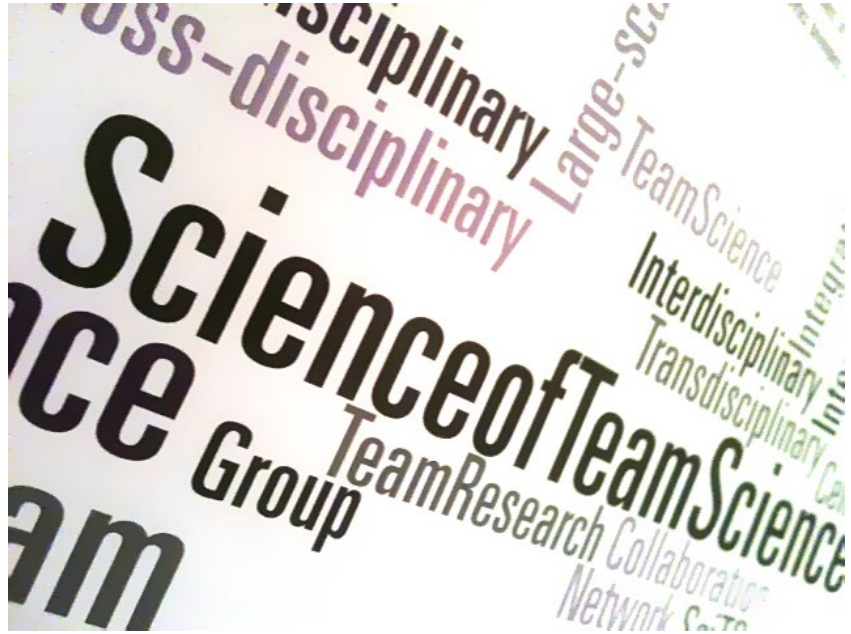


Final Thoughts About Team Science

- Teams are made of people
  - Teams are intrinsically dysfunctional
  - Cross-disciplinarity both strengthens and threatens teams
- Team science is an art & a science
  - Can be learned and must be practiced
- Reframe collaboration as a process of teamwork to be mastered
  - ***By understanding the <u>teamwork activities</u> necessary for success, we can achieve more successful collaborations***



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