Introduction to the Science of Team Science

UF Clinical and Translational Science Institute
UNIVERSITY of FLORIDA

www.ctsi.ufl.edu/

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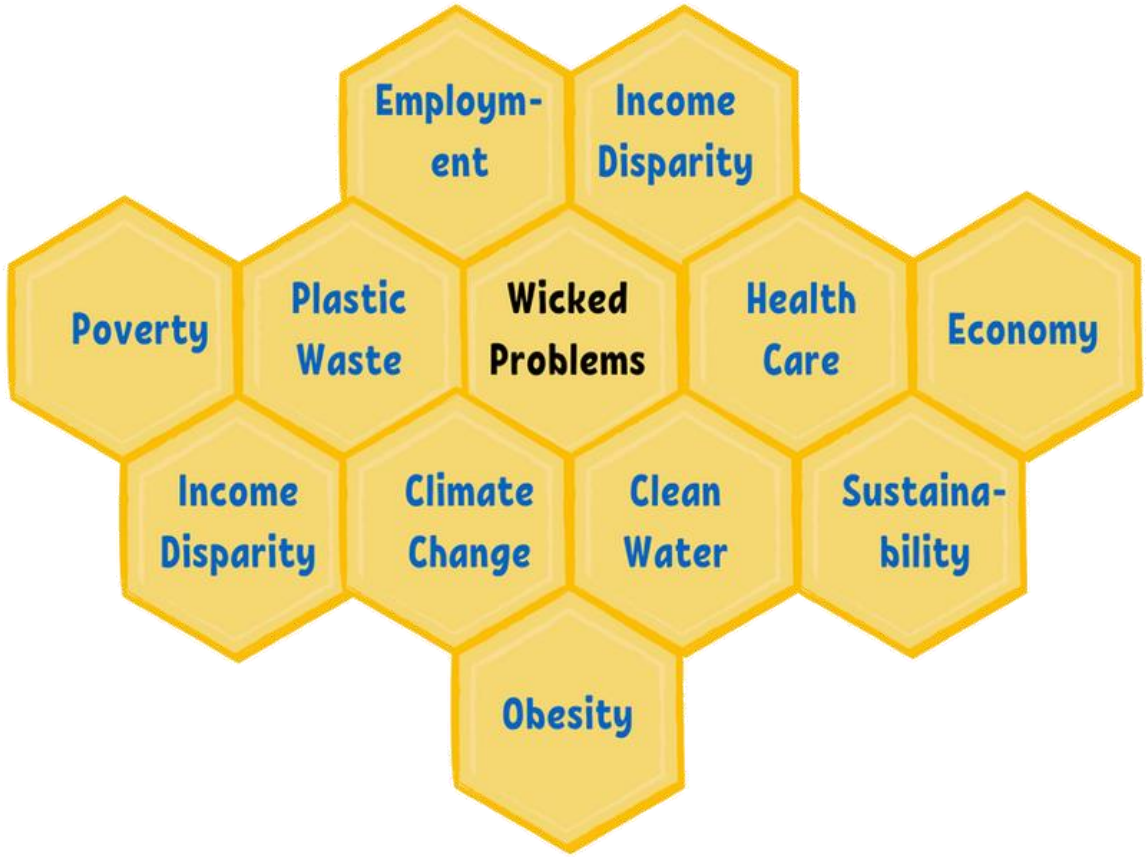
Let’s Be Interactive!

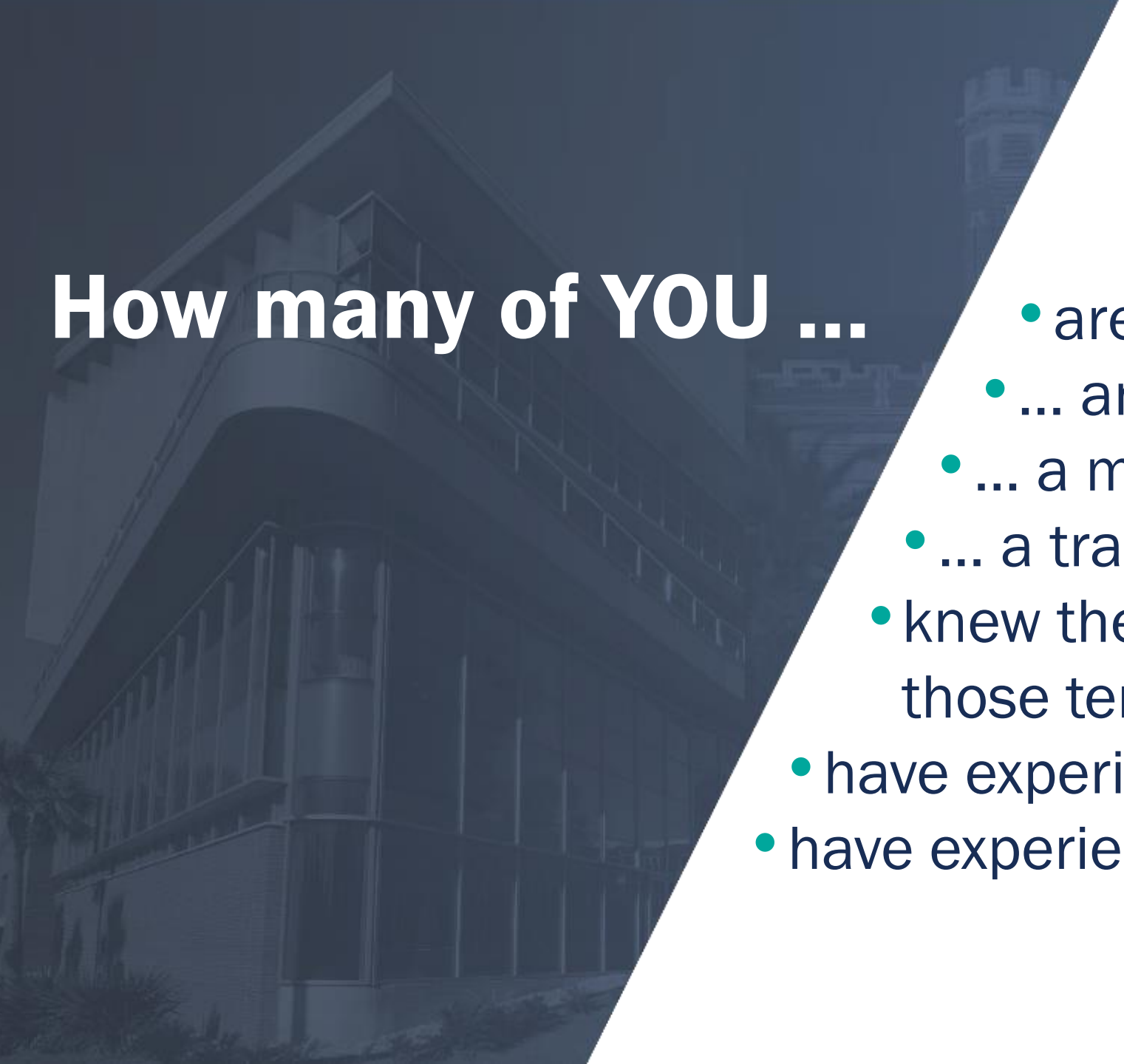
Please feel free to enter comments in Chat and to unmute yourself to respond to questions I will ask along the way!

My lens …

But what we discuss today can easily be applied to other professions and job sectors that involve collaboration

Wicked Problems





How many of YOU …

- are part of a research team?
- … an interdisciplinary team?
- … a multidisciplinary team?
- … a transdisciplinary team?
- 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*

Look for 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

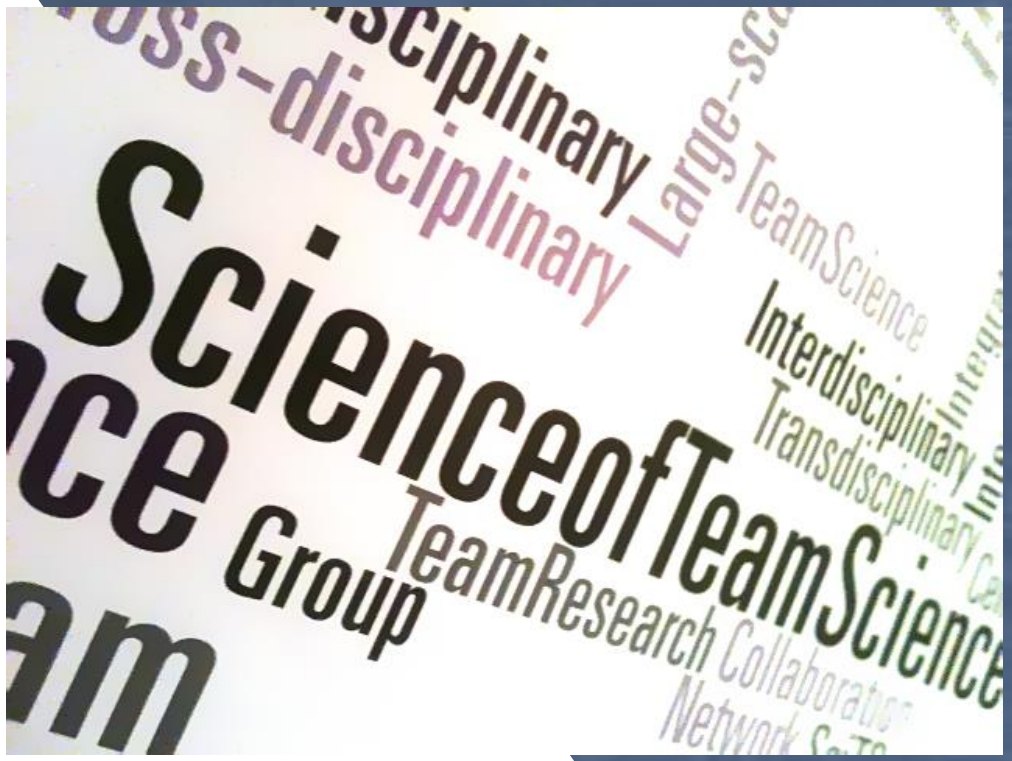
Why was that quote informative?

- 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, so why should we think anything will change?

Josef Brozek and Ancel Keys. 1944. General Aspects of Interdisciplinary Research in Experimental Human Biology. *Science* 100(2606):507-512.

Can we overcome the challenges? YES!

- Increased emphasis on collaborative research that creates teams of scientists to address complex phenomena
  - Funders (*e.g.*, NIH, NSF) 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

Can we overcome the challenges? YES!

INSciTS | Building the knowledge base for effective team science

International Network for the Science of Team Science

Definitions

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

What is a Team?

Team	**two or more people working *interdependently* (collaborating) towards a shared common goal or 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, largely on his or her own

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

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?

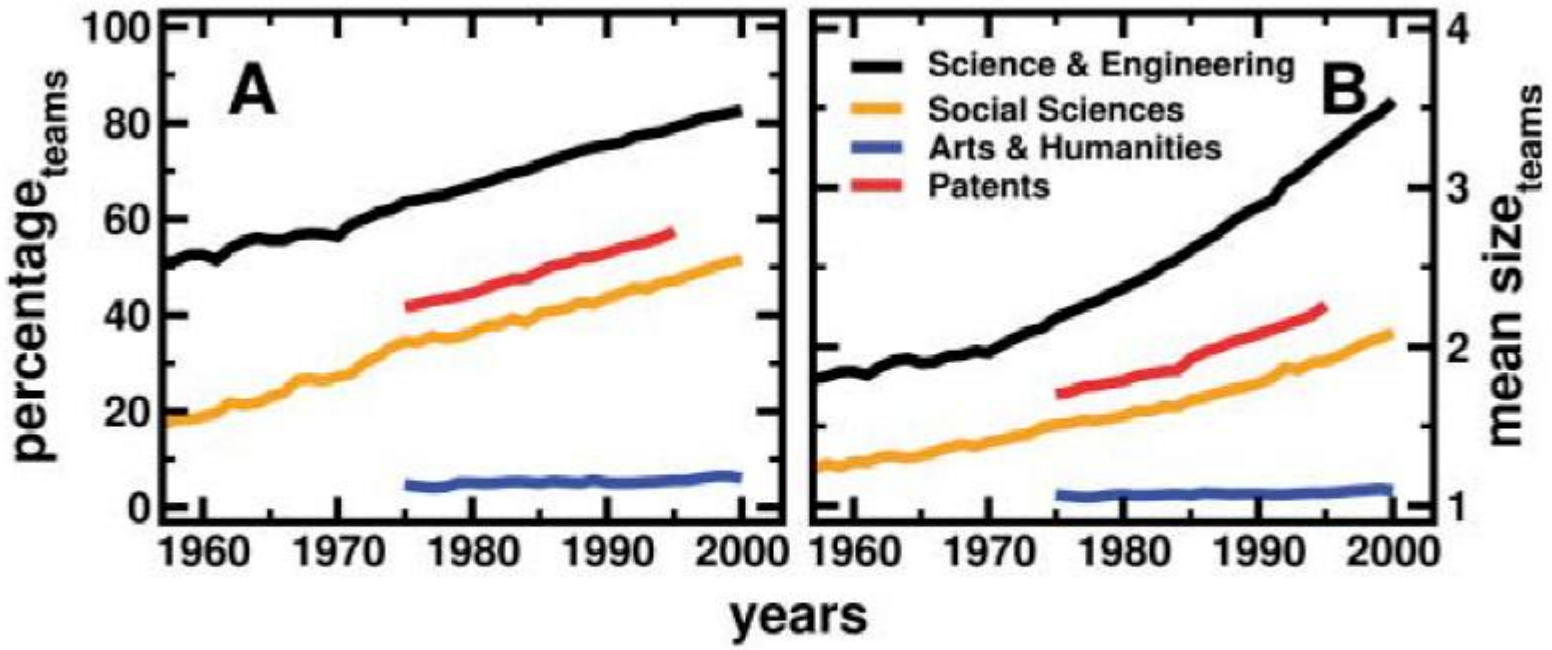


Fig. 1. The growth of teams. These plots present changes over time in the fraction of papers and patents written in teams (**A**) and in mean team size (**B**). Each line represents the arithmetic average taken over all subfields in each year.

Is the shift to teamwork seen in all fields? What is the impact of teamwork?

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	–	–

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

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How is team size related to impact?

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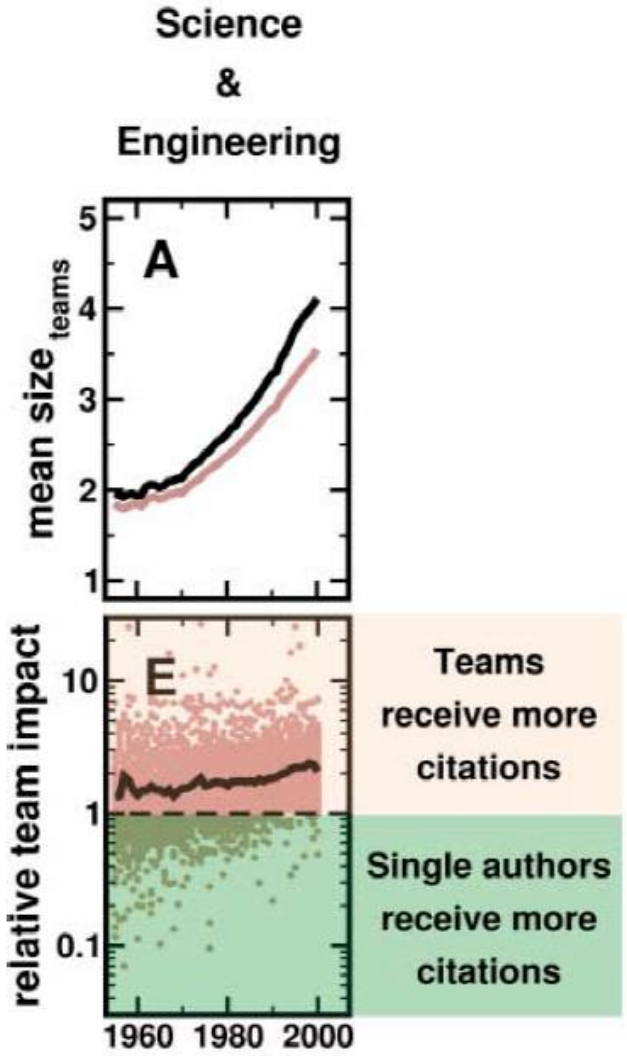


Fig. 2. The relative impact of teams. (**A** to **D**) Mean team size comparing all papers and patents with those that received more citations than average in the relevant subfield. (**E** to **H**) The RTI, which is the mean number of citations received by team-authored work divided by the mean number 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.

How is team size related to high impact work?

first 5 years
last 5 years

A, science & engineering
B, social sciences
C, arts & humanities
D, patents

Team science is more impactful than solo science

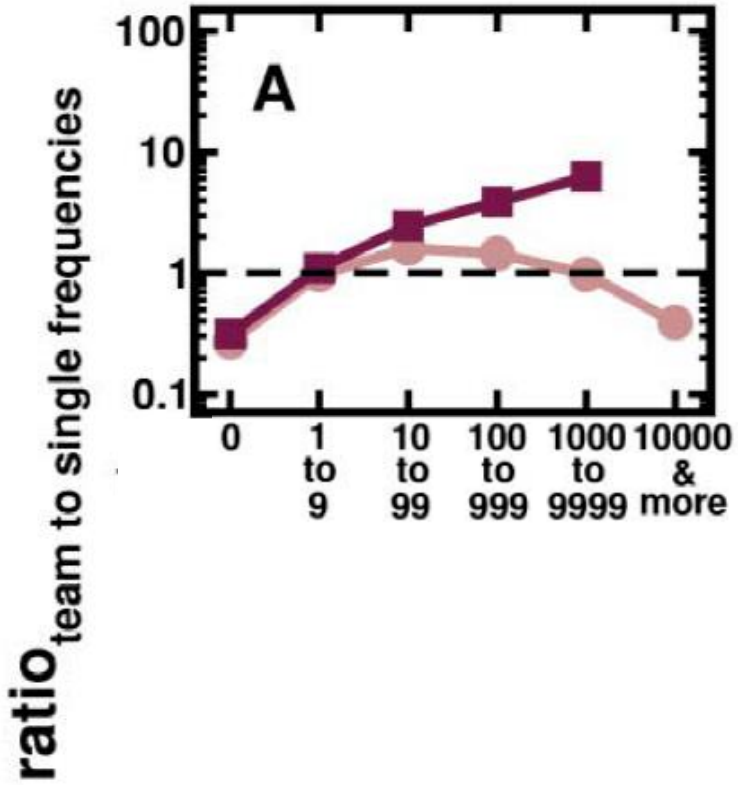


Fig. 3. Exceptional research. Pooling all publications and patents within the four research categories, we calculated frequency distributions of citations received. Separate distributions are calculated for single authors and for teams, and the ratio is plotted. A ratio greater than 1 indicates that a team-authored paper had a higher probability of producing the given range of citations than a solo-authored paper. Ratios are compared for the early period (first 5 years of available data) and late period (last 5 years of available data) for each research category, sciences and engineering (**A**), social sciences (**B**), arts and humanities (**C**), and patents (**D**).

Selecting Team Members

- Complementarity of skills: differentiation & specialization
  - Match the research question
  - Collaboration readiness & experience
  - Skill sets: specific *vs*. general
  - Problem-solving & decision-making
  - Leadership experience

- Cohesion (shared mental model & work)
  - Leads to respect and trust
- Complementarity sometimes conflicts with cohesion

How can we USE team science?

- Recognize which problems 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 individuals who must interact and adapt to achieve specified, shared, and valued objectives” (Salas, *et al*., 1992)

How can we USE team science?

- Characteristics of Teams
  - Multiple information sources
  - Intensive communication
  - Task-relevant knowledge
  - Meaningful task interdependencies
  - Coordination among members with specialized roles/responsibilities

- Reframe cross-disciplinary science as a process of teamwork to be mastered
  - *By understanding the teamwork activities necessary for success we can make the achievement of cross-disciplinary science more tractable*

Tuckman Model of Team Formation & Performance

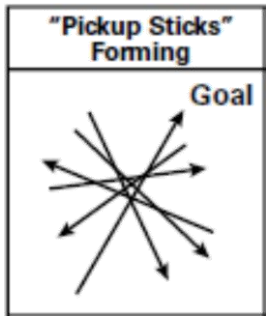
Forming
Team acquaints and establishes ground rules. Formalities are preserved and members are treated as strangers.

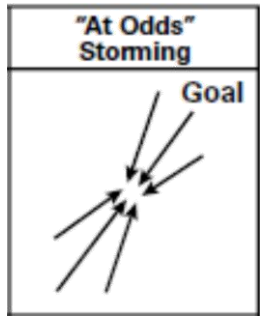
Storming
Members start to communicate their feelings but still view themselves as individuals rather than part of the team. They resist control by group leaders and show hostility.

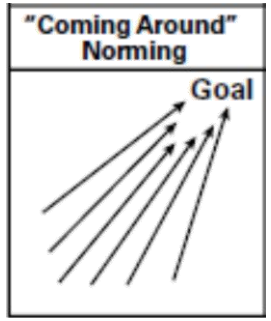
Norming
People feel part of the team and realize that they can achieve work if they accept other viewpoints.

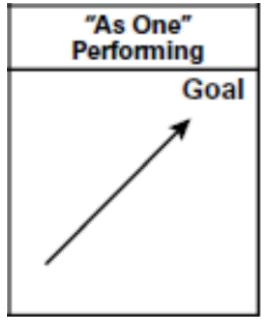
Performing
The team works in an open and trusting atmosphere where flexibility is the key and hierarchy is of little importance.

Adjourning
The team conducts an assessment of the year and implements a plan for transitioning roles and recognizing members' contributions.



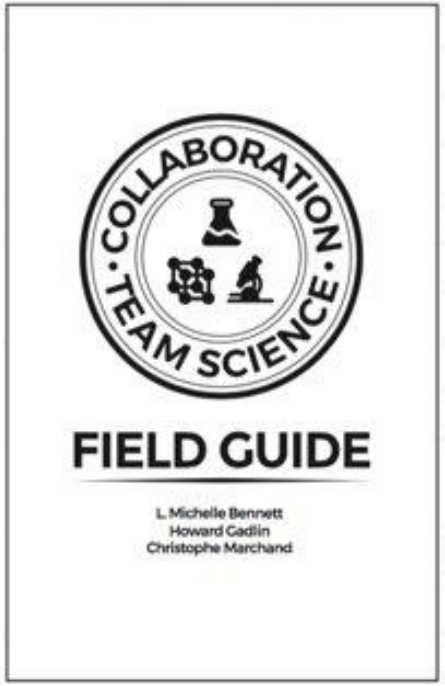






Top Ten Take-Aways

- Trust
- Vision
- Self-Awareness & Emotional Intelligence
- Leadership
- Mentoring
- Team Evolution & Dynamics
- Communication
- Recognition & Sharing Success
- Conflict & Disagreement
- Navigating & Leveraging Networks & Systems



Team Science Training for UF PhD & Dual Degree Students

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Wayne T. McCormack, PhD *mccormac@ufl.edu*
Distinguished Teaching Scholar & Professor, College of Medicine
CTSA TL1 Principal Investigator/Program Director
Director, Office of Biomedical Research Career Development

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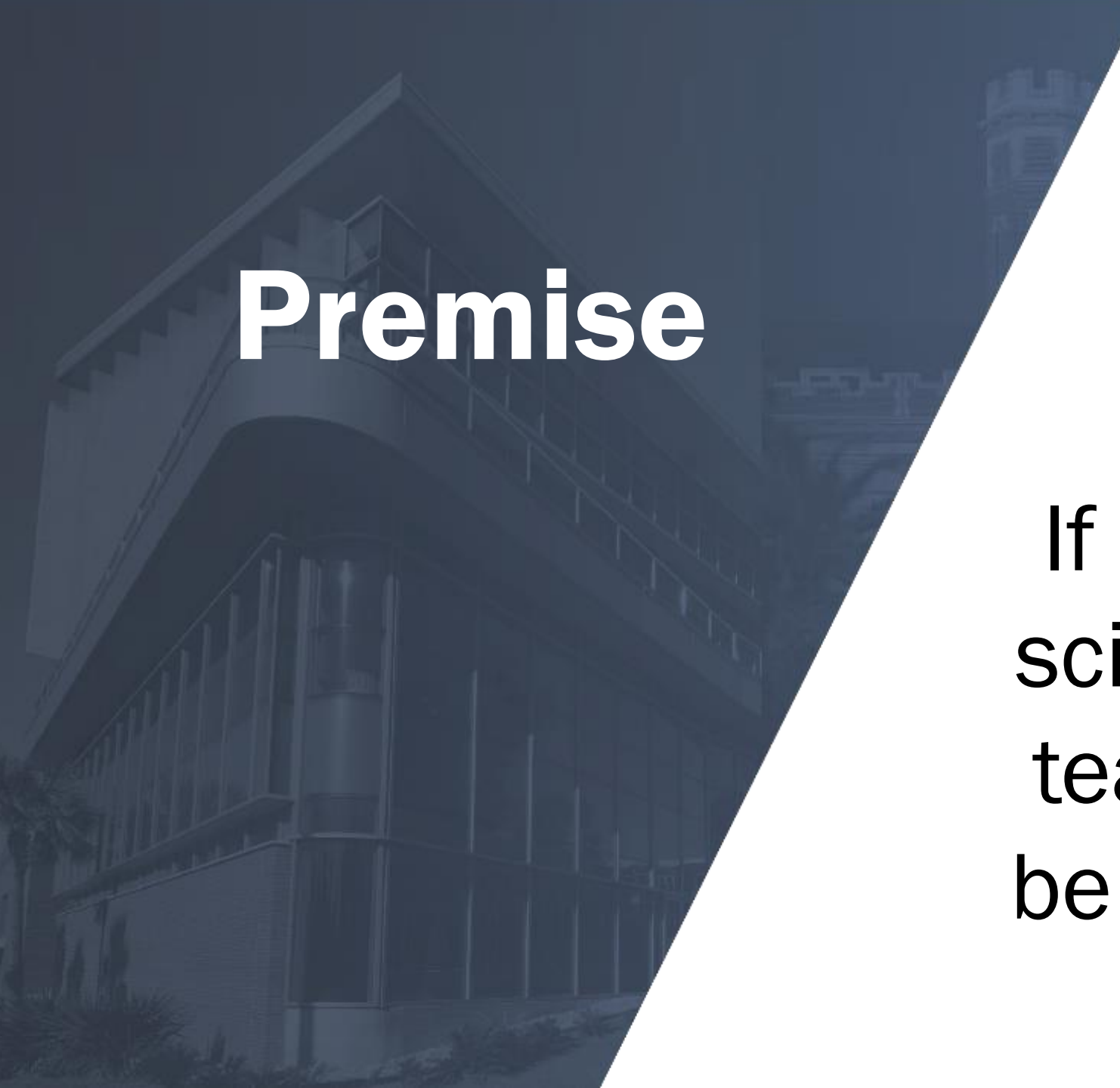
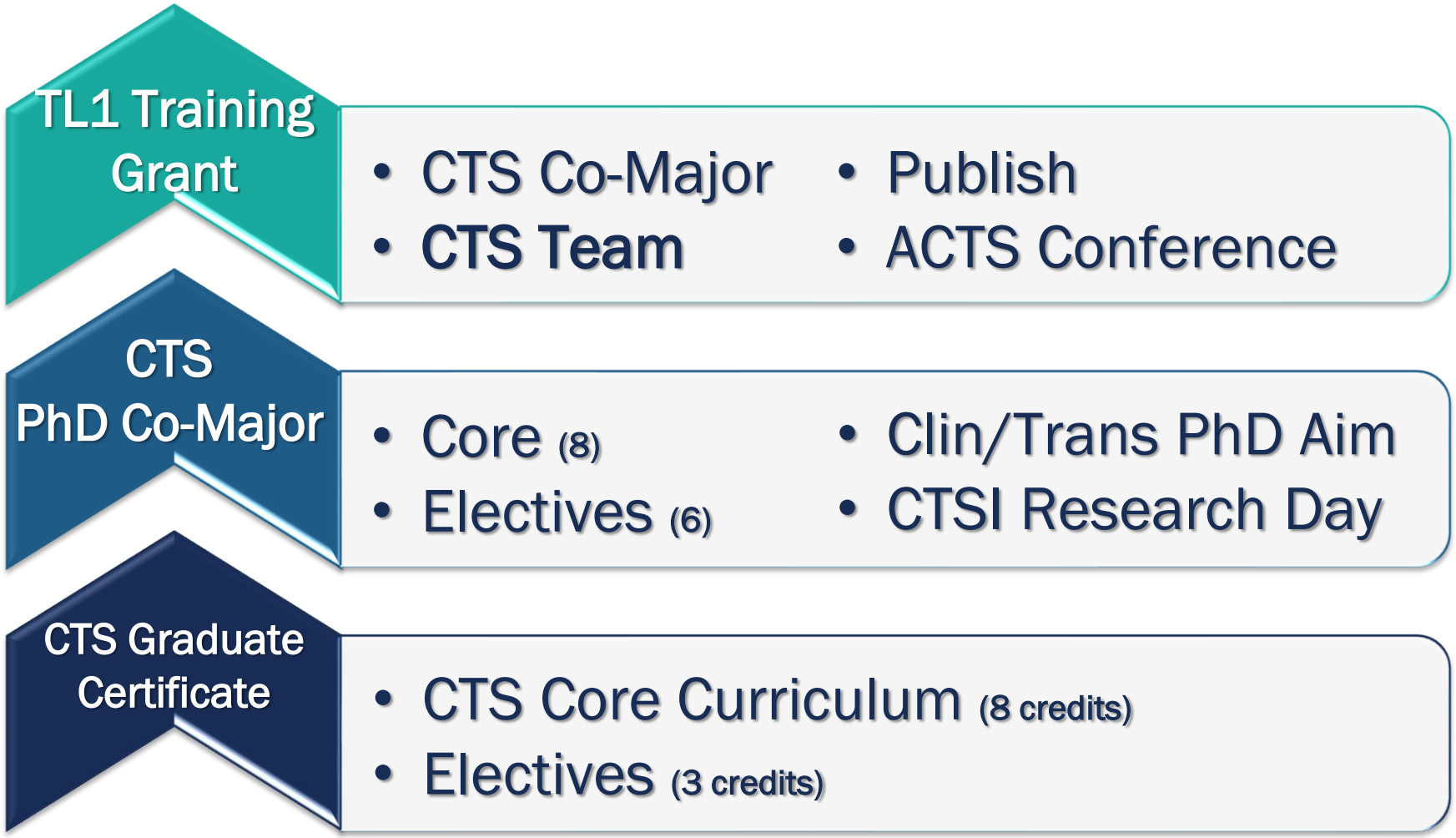


Premise

If we expect future scientists to work in teams, they should be trained in teams.

Team Science is Embedded in UF Clinical & Translational Science Programs



Didactic & Practical:
Team Science (GMS 6945)

- Intro to Team Science
- Preparing for Team Science
- Team Leadership
- Building a Research Team
- Writing a Collaboration Plan
- Managing Research Teams
- Conflict Management
- Team Monitoring
- Team Evaluation

Behavioral Self-Assessment (DISC)

Vision & Mission Statement

Collaboration Plan

Authorship Agreement

Team Dimensional Training

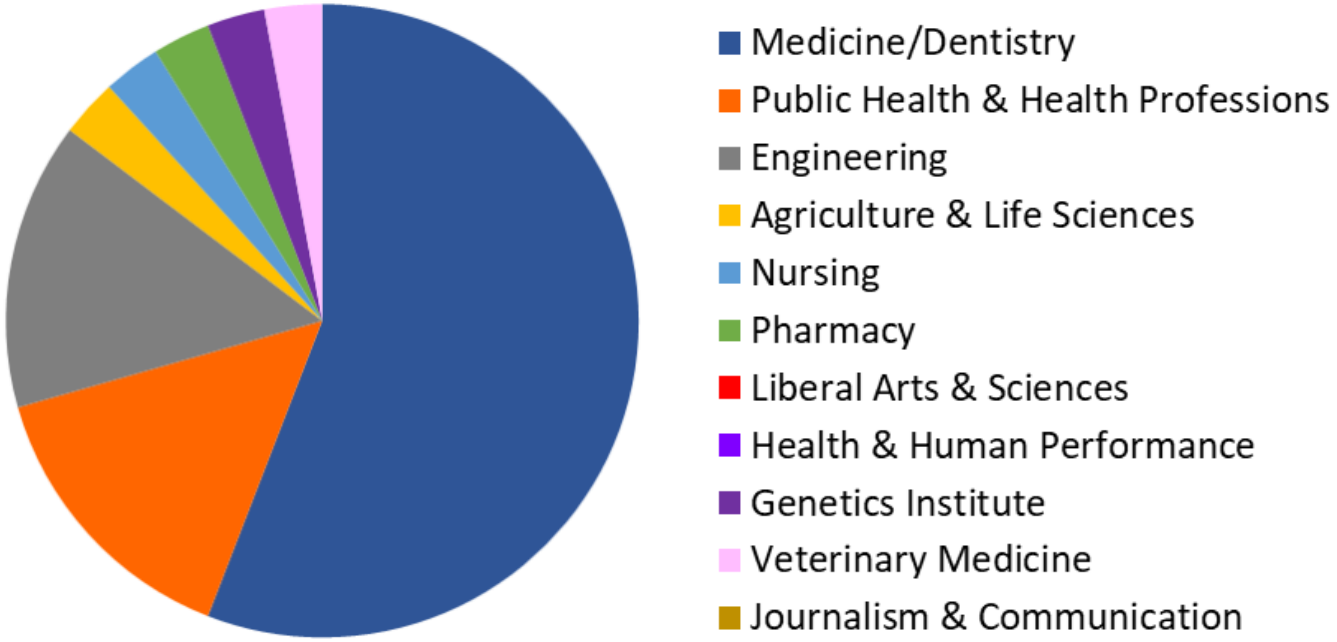
Evaluation Plan

Practical: CTS Teams

- Team members must be from
  - different PhD programs
  - in different colleges from different labs
- CTS Team Co-Mentors
- Extent of CTS Team collaboration
  - Team specific aim(s)
    - Barrier to progress addressed by collaboration, or expand scope
    - Level of interdependence
    - Synergy between individual projects
  - Embed into individual dissertation research projects

TL1 Trainee Home Colleges

Individual TL1 Trainees (2009-16)



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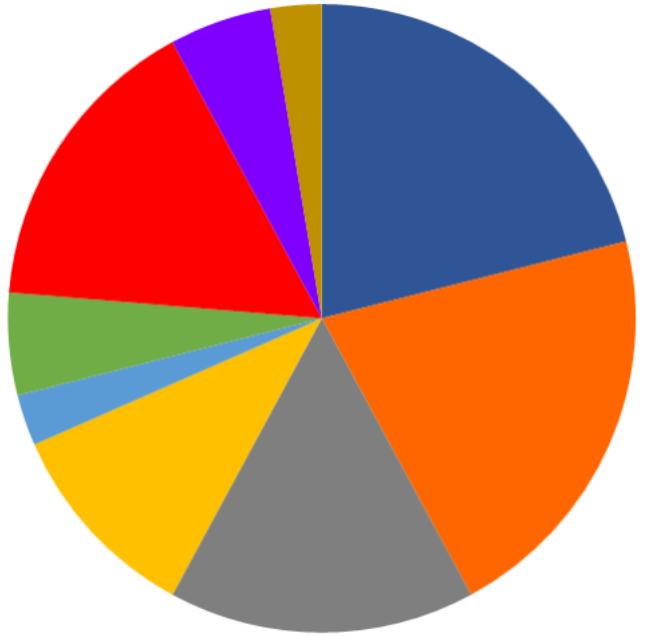
CTS Team Members (2016-21)



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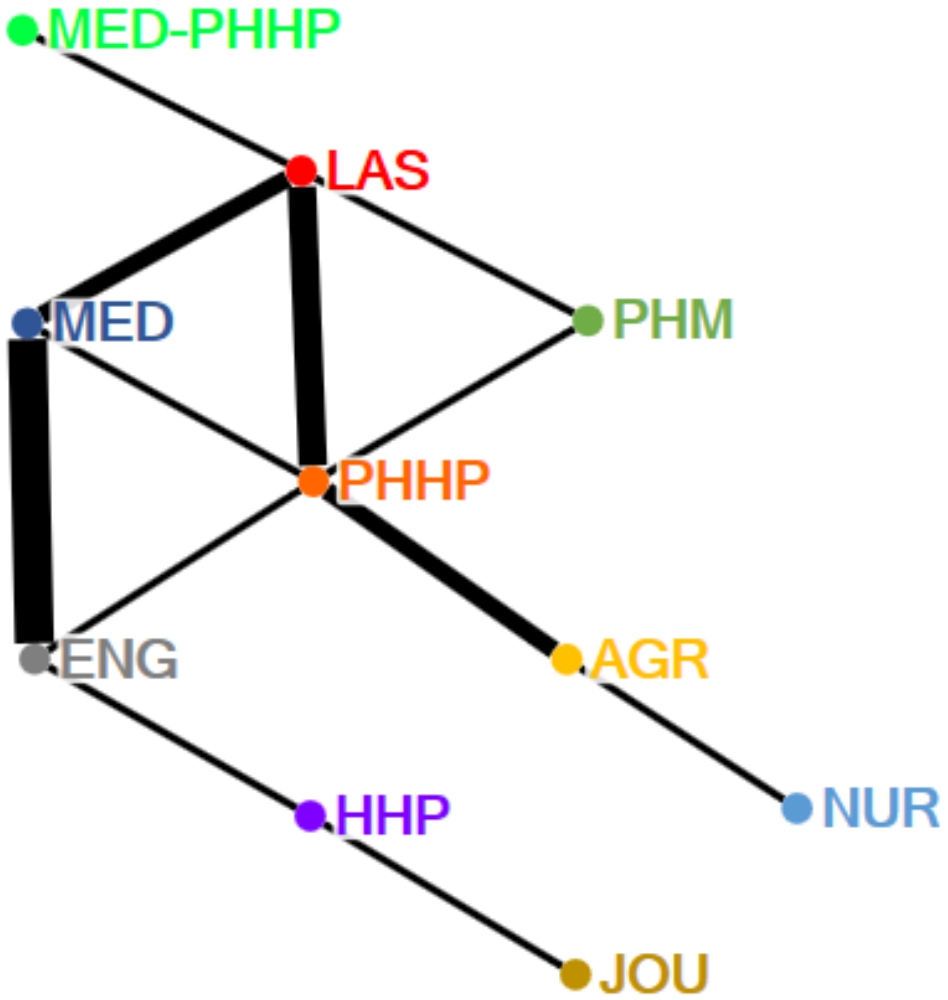
CTS Team Member Home Colleges



AGR = Agriculture & Life Sciences
ENG = Engineering
HHP = Health & Human Performance
JOU = Journalism & Communication
LAS = Liberal Arts & Sciences
MED = Medicine
MED-PHHP = Medicine & PHHP
NUR = Nursing
PHHP = Public Health & Health Prof
PHM = Pharmacy

“The team aspect was particularly motivating for me. Working in a collaboration added a different blend to my work.”

“It was also fun to be able to work on a part of my dissertation with another student”

“It has opened opportunities and collaborations that I otherwise would not have pursued. The team-based approach is novel and enriching and by far the highlight of this program.”

- TL1 Trainees

Brozek & Keys in *Science*, 1944

"In the training program three points deserve emphasis: (1) facilities for **getting acquainted with the problems and methods of the neighbor fields**, (2) **study of the 'science of science'** which provides the necessary philosophical perspective, and (3) development of **social skills required for a stimulating and efficient scientific cooperation**."

Josef Brozek and Ancel Keys. 1944. General Aspects of Interdisciplinary Research in Experimental Human Biology. ***Science*** 100(2606):507-512.

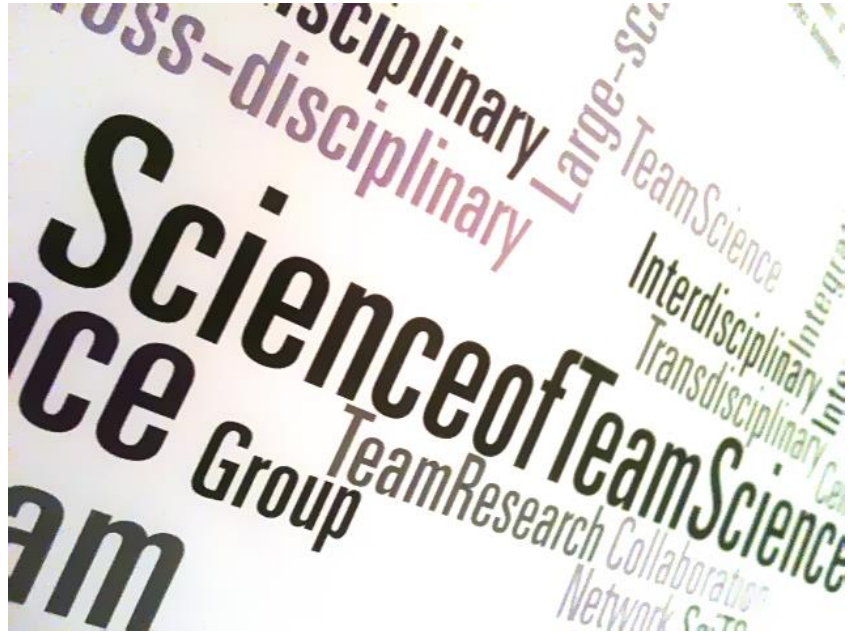
How can we learn more?

- GMS 6945, Team Science
- GMS 6847, Translational Research and Therapeutics: Bench, Bedside, Community, & Policy
- Learn-Discover-Lead Professional Development Seminar Series (https://graddev.ufhealth.org/) Second Fridays of the month

- For faculty:
  - *Team Science* Academy

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 teamwork activities necessary for success, we can achieve more successful collaborations***



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