Convergence, Grand Challenges, Team Science, and Inclusion

NSF EFRI Workshop
Convergence and Interdisciplinarity in Advancing Larger Scale Research
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Outline

Convergence

Grand Challenges

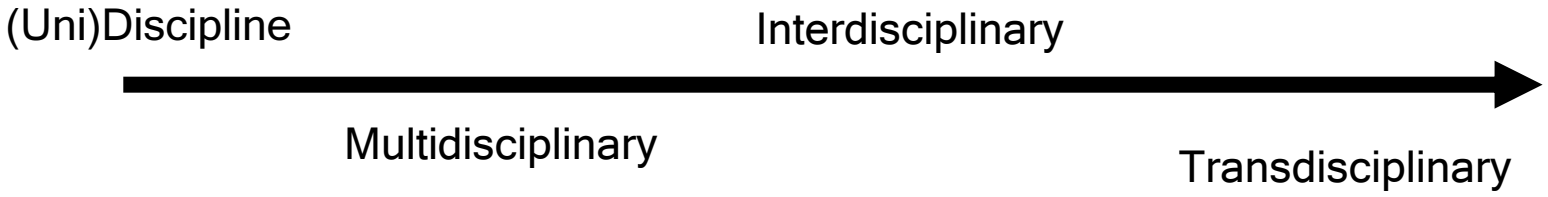
Team Science

Inclusion and Diversity

Conclusions

Definitions and Terminology

What is Convergence?



Source: Hall, 2014

Disciplines and Multidisciplinary

Discipline: particular branch of learning or body of knowledge

Multidisciplinarity: juxtaposition of two or more disciplines on a question, problem, topic, or theme.

- **Juxtaposition** of disciplines that remain separate
- Individuals **work separately,** results typically published separately or compiled, but **not synthesized.**

Source: Hall, 2014

Interdisciplinary

Interdisciplinary: integration of information, data, methods, tools, concepts, and/or theories from two or more disciplines

- Key defining concept: **integration**
- Individuals may work alone, but increasingly research is **team-based.**
- Collaboration introduces **social integration**, project management and communication.

Source: Hall, 2014

Transdisciplinary

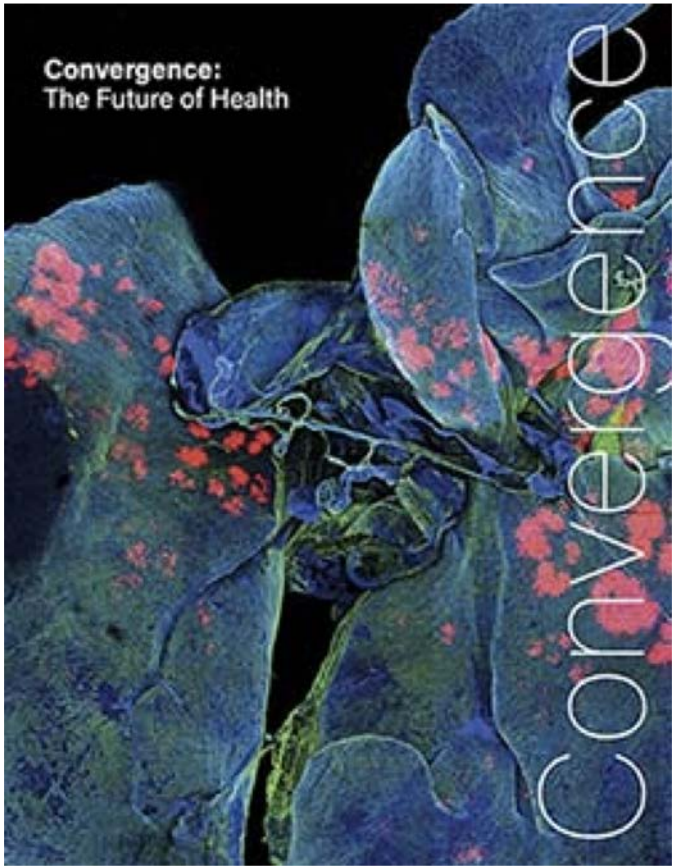
Transdisciplinary: transcend disciplinary approaches through comprehensive frameworks and paradigms

- **Problem-oriented** research that crosses the boundaries of both academic and public and private spheres.
- **Mutual learning**, joint work, and knowledge integration are key to solving “real-world” problems.
- Beyond interdisciplinary combinations to foster **new worldviews** or domains.

Source: Hall, 2014

Recent Reports and Studies

MIT 2016



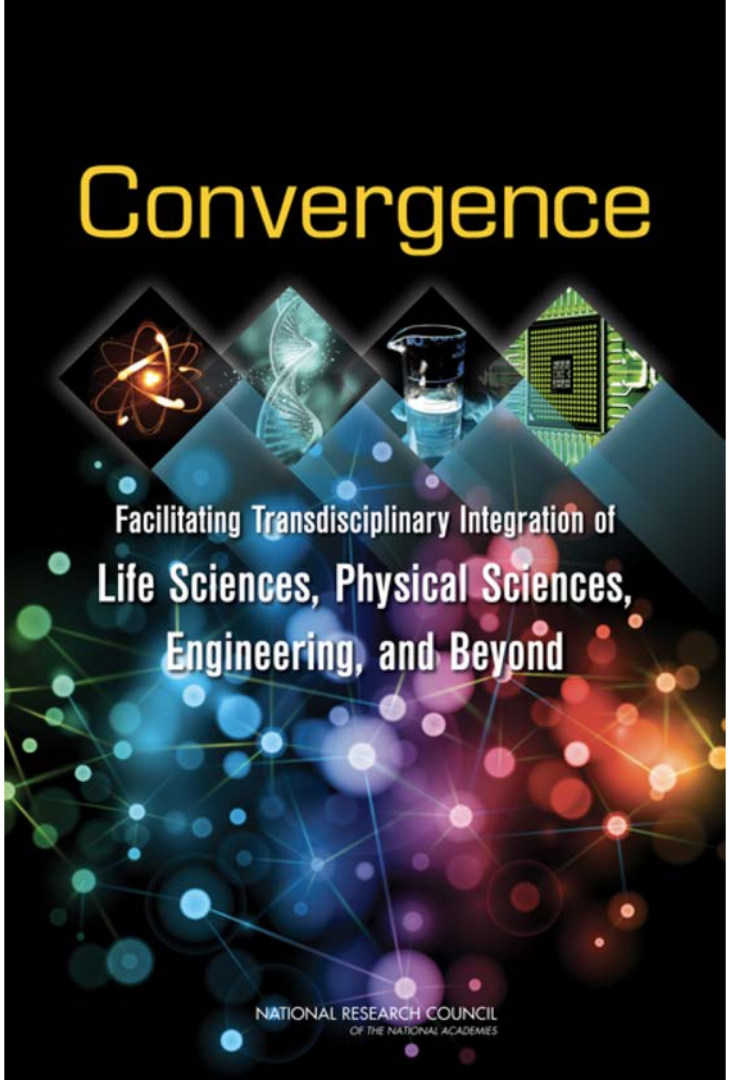
MIT Report - Convergence: Future of Health

"Convergence as applied to health … **integrates** expertise from life sciences with physical, mathematical, and computational sciences, as well as engineering, to form **comprehensive** frameworks … "

"… convergence goes beyond collaboration … involves **integration** of historically distinct disciplines and technologies into a **unified** whole … integration … offers **potentially revolutionary change** for biomedical sciences."

Sharp et al 2016, Science,
Capitalizing on convergence for health care

NRC 2014


Convergence
Facilitating Transdisciplinary Integration of
Life Sciences, Physical Sciences,
Engineering, and Beyond
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

NRC Report on Convergence

Convergence is an approach to **problem solving** … **integrates** knowledge, tools, and ways of thinking .. a **comprehensive synthetic framework** for tackling scientific and societal challenges ...

Two closely related but distinct properties:

- convergence of expertise
- formation of the web of partnerships.

Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

Four Key Pillars

- People
- Organization
- Culture
- Ecosystem

Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

People

- Students, faculty and staff
- Department chairs
- Deans
- Leadership
- Communicate across disciplines building from deep expertise

Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

Organization

- Goal-oriented vision
- Program management
- Support for core facilities
- Catalytic/seed funding
- Reward risk-taking
- Governance systems

Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

Culture

- Mutual respect
- Opportunities to share knowledge
- Diversity of perspectives
- Inclusive
- Risk taking

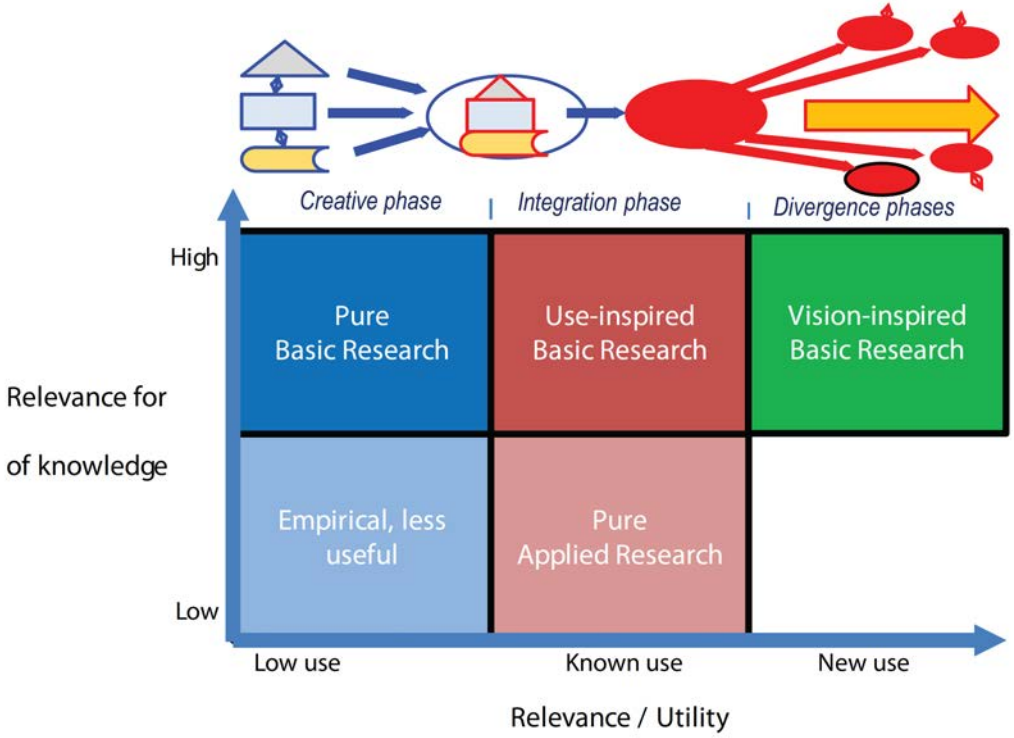
Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

Ecosystem

- Dynamic interactions at various levels
- Multiple partners
- Within institution
- Across institutions
- Academic-industry-foundations-government

Source: Convergence: Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond, NRC, 2014

Convergence and Pasteur's Quadrant



Source: Roco et al, 2013

NSF Big Idea: Growing Convergence Research

Convergence Research has two primary characteristics:

A. **Research driven by a specific and compelling problem:**

Need to address a specific challenge or opportunity,
From deep scientific questions or pressing societal needs.

B. Deep integration across disciplines:

Knowledge, theories, methods, data, research communities and languages **intermingled or integrated**.
New **frameworks, paradigms or disciplines** from sustained interactions …

https://www.nsf.gov/pubs/2018/nsf18058/nsf18058.jsp?WT.mc_id=USNSF_25&WT.mc_ev=click

Convergence and Pressing Societal Needs

=

Grand Challenges?

NAE Grand Challenges

GRAND CHALLENGES FOR ENGINEERING


Make solar energy economical


Provide energy from fusion


Develop carbon sequestration methods


Manage the nitrogen cycle


Provide access to clean water


Restore and improve urban infrastructure


Advance health informatics


Engineer better medicines


Reverse-engineer the brain


Prevent nuclear terror


Secure cyberspace


Enhance virtual reality


Advance personalized learning


Engineer the tools of scientific discovery

GRAND CHALLENGES FOR ENGINEERING

UN Sustainable Development Goals

UK Industrial Strategy: the Grand Challenges

- Growing the Artificial Intelligence and data driven economy
- Clean growth
- Future of mobility
- Ageing society

https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges

EU Horizon 2020 Grand Challenges

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

https://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

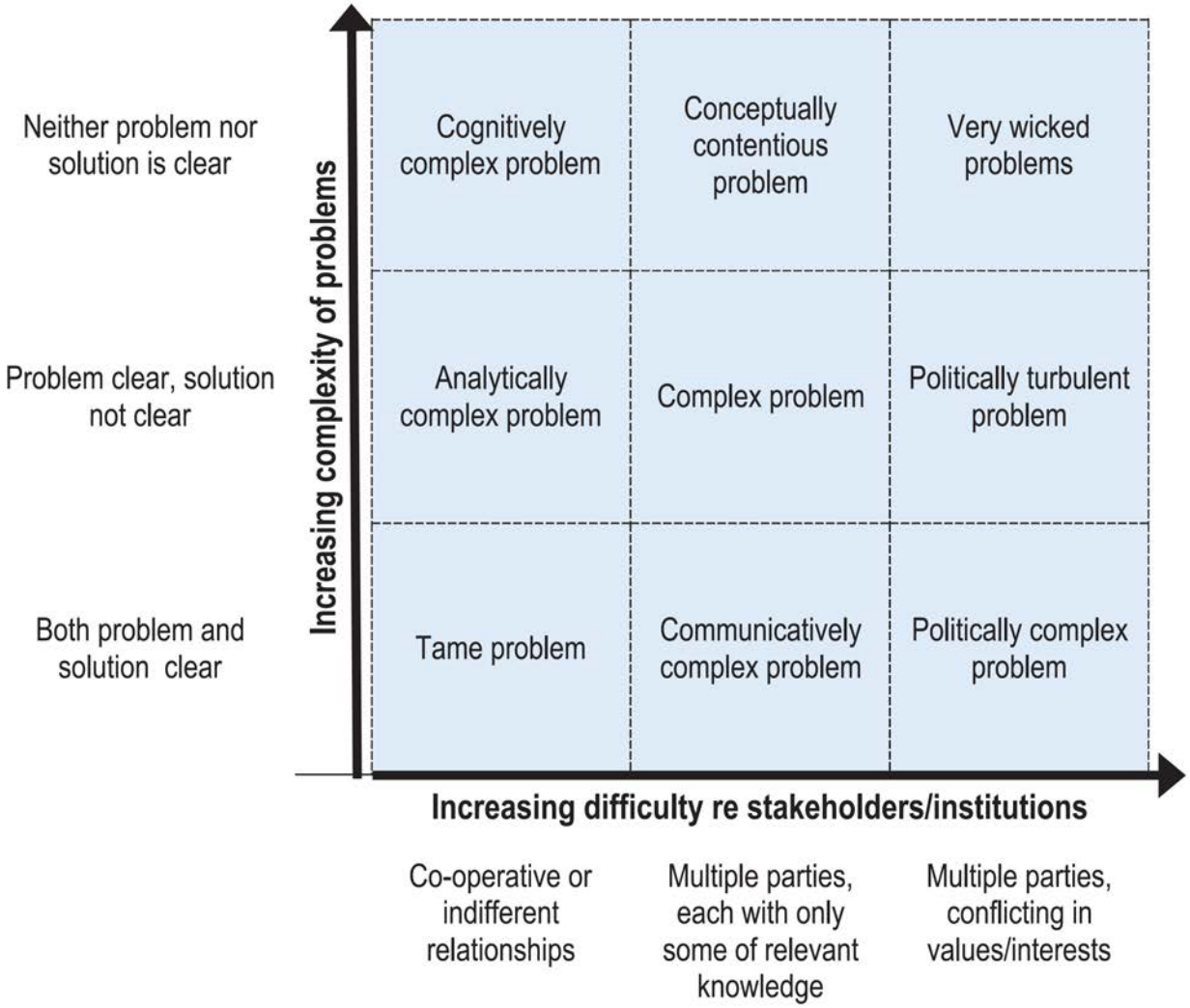
Grand Challenges are often Wicked Problems

Wicked problems … there is no clear stopping rule … working on it more … better solution … no single right answer … every attempt can matter because it affects the things people depend upon.

Horst and Rittel, 1973

Characteristics of Wicked Problems

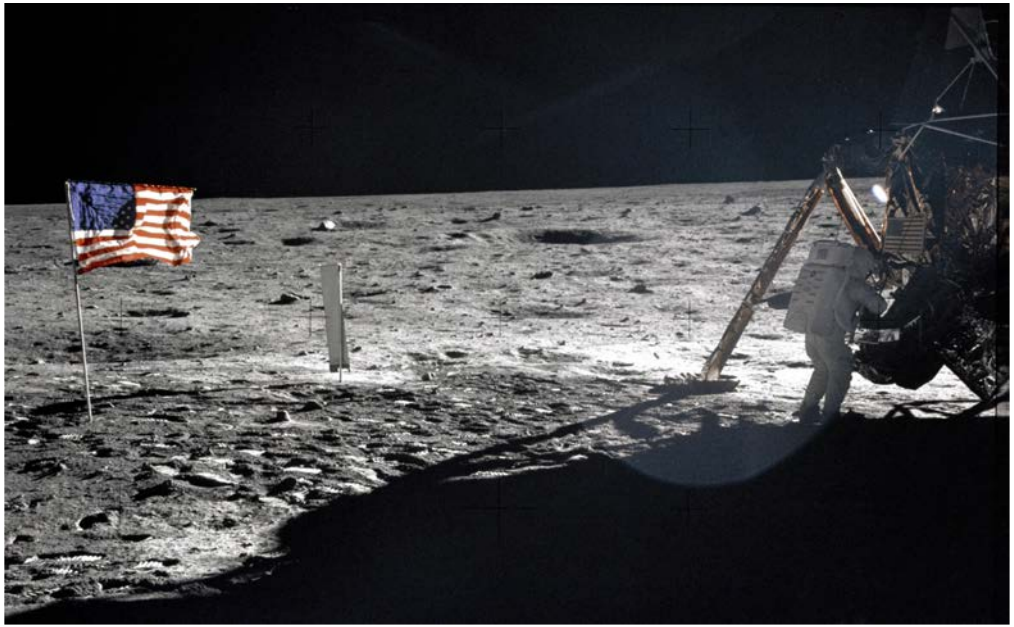
- No definite formulation of a wicked problem.
- No stopping rules.
- Solutions are not true-or-false, but better or worse.
- No immediate and no ultimate test of a solution to a wicked problem.
- Do not have an enumerable (or an exhaustively describable) set of potential solutions
- Every wicked problem is essentially unique.
- Causes can be explained in numerous ways.



Alford and Head, 2017
Wicked and less wicked problems: a typology and a contingency framework
Policy and Society, 36:3, 397-413

Examples

President John F. Kennedy speaks before a joint session of Congress, May 25, 1961

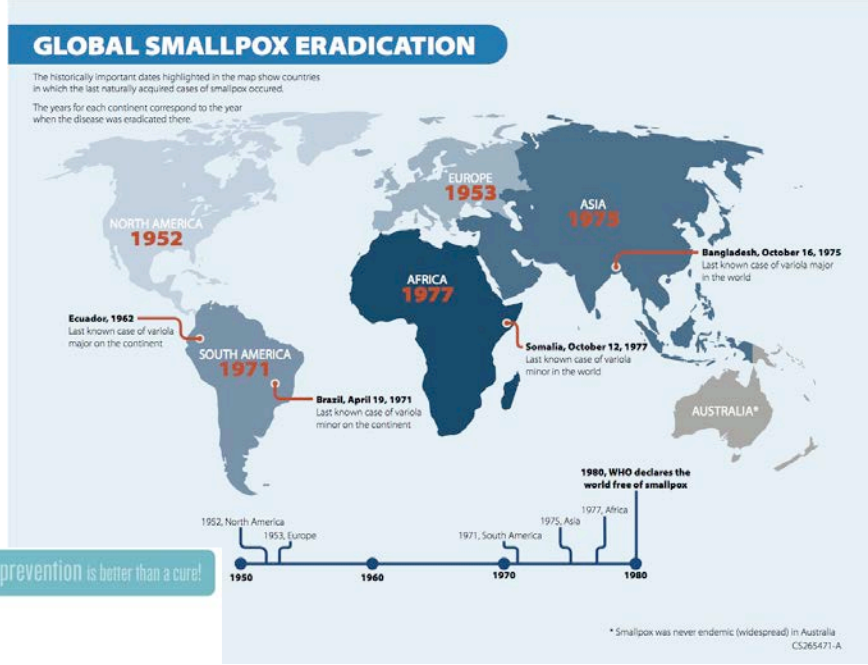


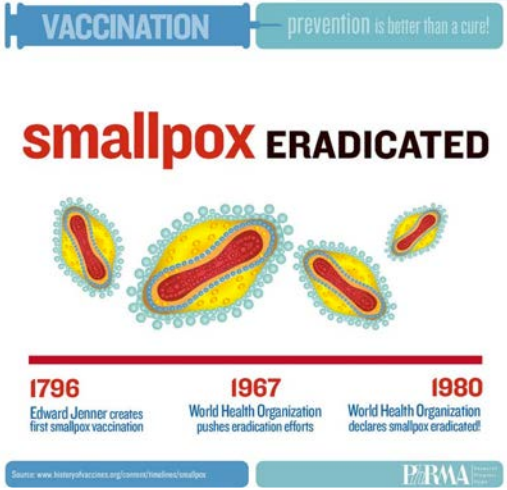
Apollo 11, July 20, 1969
Neil Armstrong: One Giant Leap For Mankind

Source: NASA

Edward Jenner
“On the Origin of the Vaccine Inoculatior
1801

“the annihilation of the smallpox, the most dreadful scourge of the human species, must be the final result of this practice.”





1881

1911

1930's

1953

1990

The most anticipated transit projects opening in time for the 2028 LA Olympics

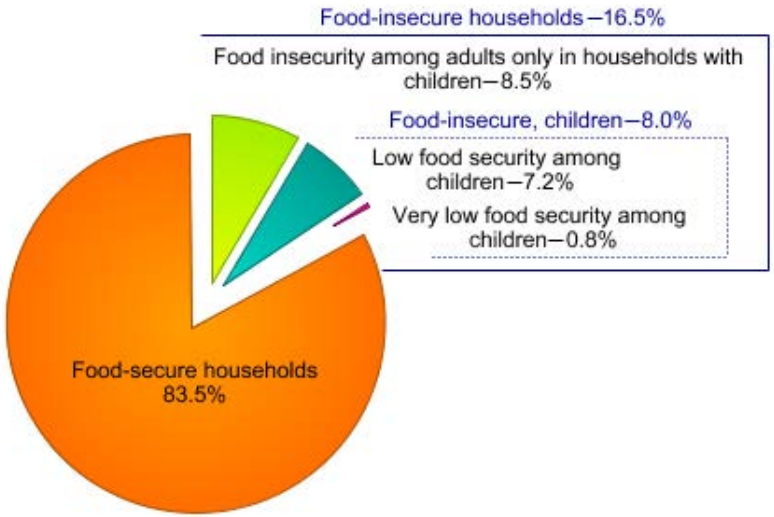
From the subway extension to the Westside to a people mover at LAX

Contemporary Examples

- Obesity and diabetes
- Food-energy-water nexus
- Low carbon society
- Automation, jobs, and future of work

Food Insecurity

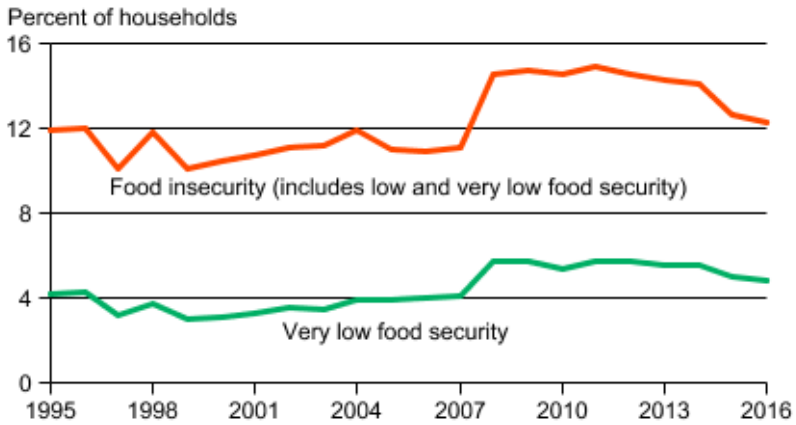
U.S. households with children by food security status of adults and children, 2016



Note: In most instances, when children are food insecure, the adults in the household are also food insecure.

Source: USDA, Economic Research Service, using data from the December 2016 Current Population Survey Food Security Supplement.

Trends in prevalence rates of food insecurity and very low food security in U.S. households, 1995-2016



Note: Prevalence rates for 1996 and 1997 were adjusted for the estimated effects of differences in data collection screening protocols used in those years.

Source: USDA, Economic Research Service, using data from Current Population Survey Food Security Supplement.

Education

‘It’s tragic’: Students go hungry in Northern Virginia

Volunteers with Food for Neighbors, an organization that seeks to help end student hunger in the Herndon community, unpack canned goods, granola bars and other donated food collected from Fairfax residents’ doorsteps at Herndon Middle School on May 5. (Debbie Truong/The Washington Post)

Most

1

2

3

4

5

Our

Play

https://www.washingtonpost.com/local/education/its-tragic-students-go-hungry-in-northern-virginia/2018/05/13/4918dd44-5236-11e8-9c91-7dab596e8252_story.html?utm_term=.4204bdeb4bbf

Next Green Revolution

https://www.nytimes.com/2016/01/04/opinion/we-need-a-new-green-revolution.html

OP-ED CONTRIBUTORS

We Need a New Green Revolution

By Phillip A. Sharp and Alan Leshner

Jan. 4, 2016

…one that goes beyond advancing production to focus on reducing exorbitant rates of food loss

Zia Khan
Rockafeller Foundation

https://www.nytimes.com/2016/01/14/opinion/what-the-next-green-revolution-will-require.html

Small-scale farmers still feed a majority of the world and must therefore be at the center of any future agricultural research agenda.

R. Offenheiser
President, Oxfam America

Innovations at the Nexus of Food, Energy and Water Systems (INFEWS)

PROGRAM SOLICITATION
NSF 16-524

National Science Foundation

Directorate for Geosciences

Directorate for Engineering

Directorate for Computer & Information Science & Engineering

Directorate for Mathematical & Physical Sciences

Directorate for Social, Behavioral & Economic Sciences

Directorate for Education & Human Resources

Office of International Science and Engineering

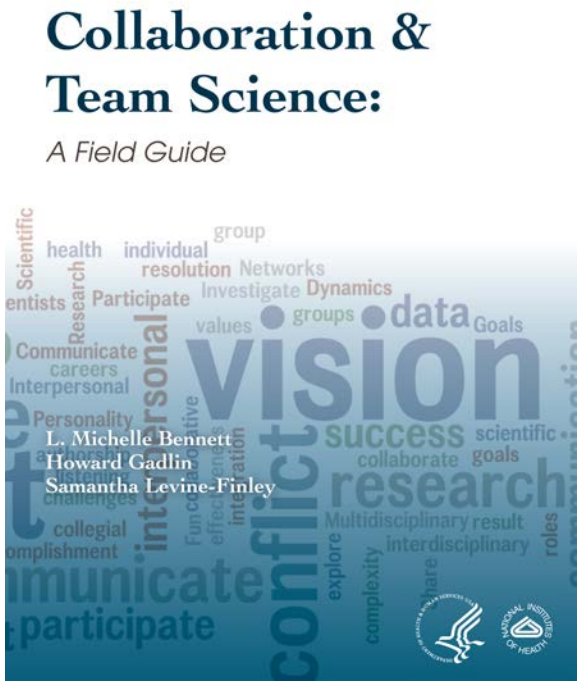
Office of Integrative Activities

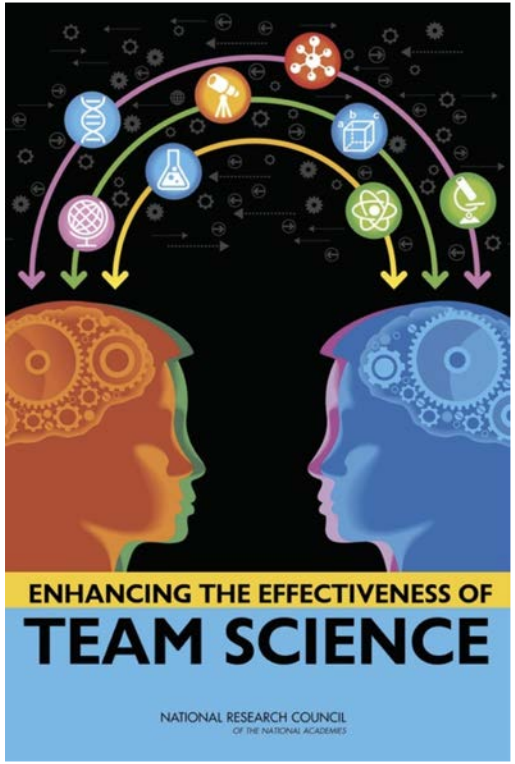
National Institute of Food and Agriculture

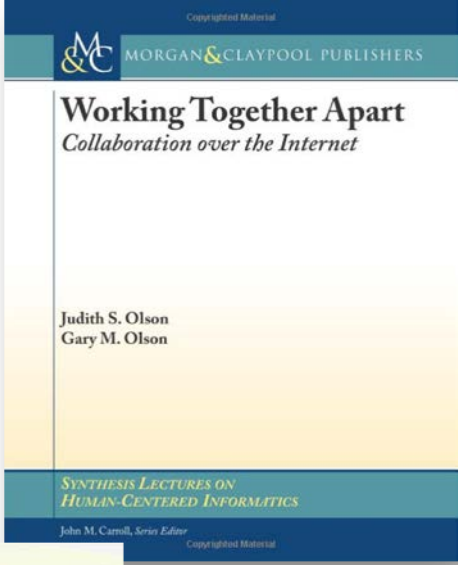
Full Proposal Deadline(s) (due by 5 p.m. submitter's local time):

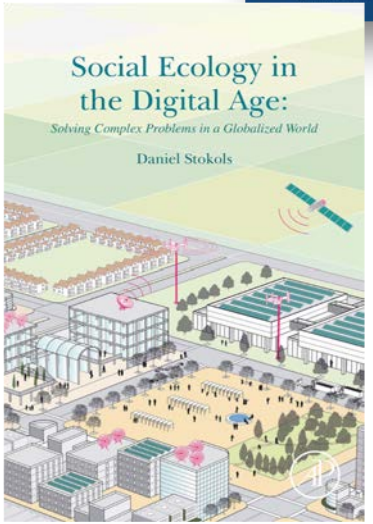
March 22, 2016

Convergence and Team Research







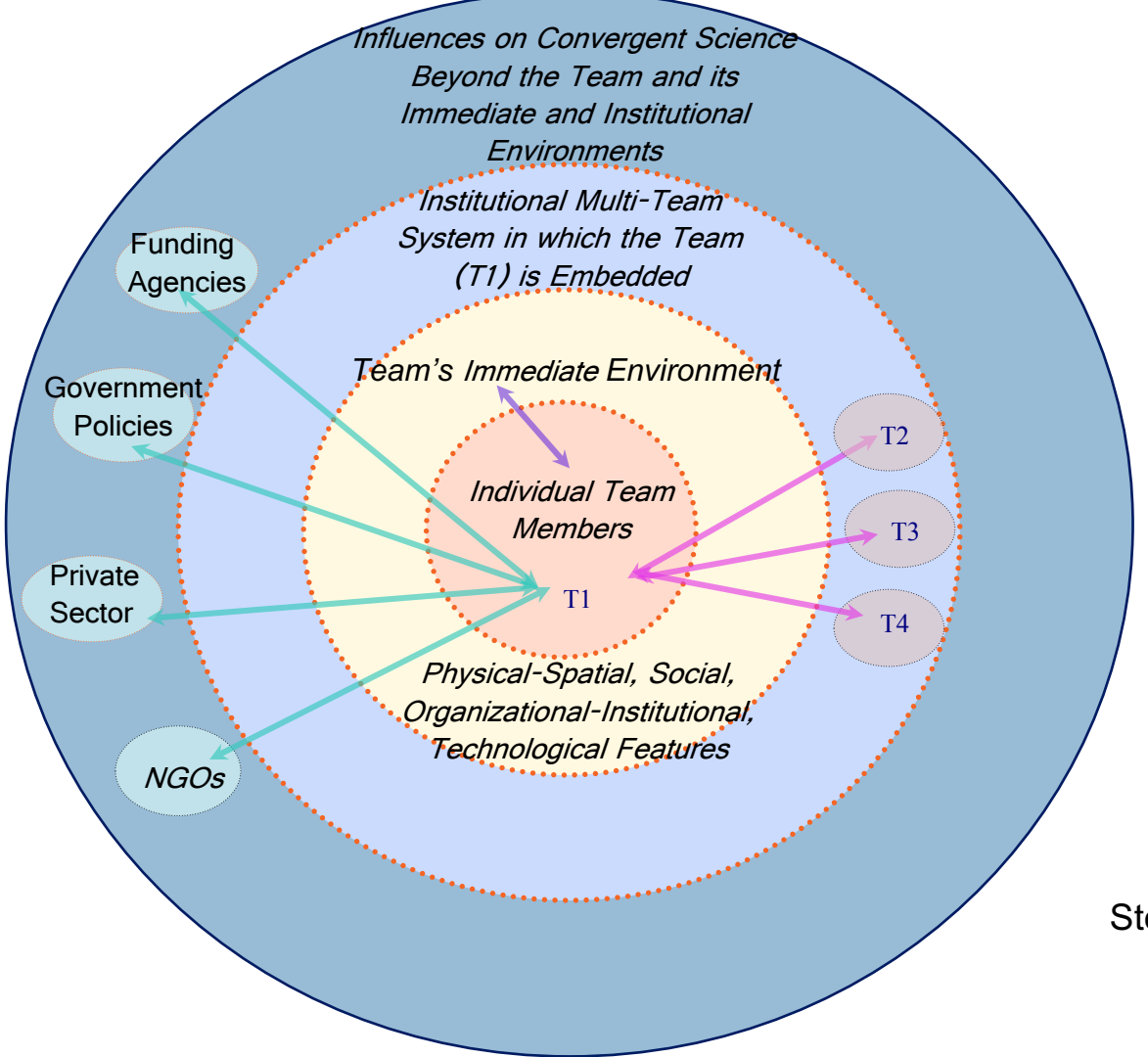


Dimensions of Team Science

- Diversity of team members
- Disciplinary integration
- Team size
- Goal alignment
- Permeable boundaries
- Geographic proximity
- Task interdependence

a new interdisciplinary field . . . aims to better understand ... team-based research and practice and to identify the unique outcomes of these approaches ... (Stokols et al.)

Source: Enhancing Effectiveness of Team Science, NRC, 2015



Stokols, 2018

Improving Team Effectiveness

- Team processes
- Team composition
- Team professional development
- Leadership for team science
- Support for virtual collaboration
- Organizational support for team research

Source: Enhancing Effectiveness of Team Science, NRC, 2015

Inclusion and Diversity in Convergence

"A central **hypothesis** of convergence is that diverse teams are able to generate innovative solutions **...**

... an environment where opinions—especially **dissenting** opinions—are **openly expressed**, where **diversity is valued**, and opposing ideas are **respectfully communicated** may be vital to the success ...."

Source: Convergence, NRC, 2016

Types of Diversity and Implications

Diversity

- Problem-solving approaches (functional)
- Demographic, cultural, and ethnic backgrounds (identity)

Relationship with team performance:

- Challenges in social integration and communication
- Perspective can mitigate and … reverse these effects
- Greater creativity and satisfaction
- Environment with diverse views and perspectives can be uncomfortable.
- Inclusive attitudes, management strategies critical to success

Source: Convergence, NRC, 2016

Additional Tools

- Design Thinking
- Lean Techniques
- Collective Impact
- NSF Innovation Corps
- NSF GERMINATION
- NSF Convergence Accelerators
- NSF INCLUDES

Concluding Remarks

- Convergence - a new vision and framework for research
- Success will require careful thinking about problem conceptions and solution criteria
- Science of team research to maximize successes and minimize costs
- Diversity is an asset and strength and inclusive culture needs to be cultivated
- **Engineering is well-positioned to lead convergent research**

21st century challenges demand successful convergent research

Comments

Ideas

Questions?

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