Team Science from an Interdisciplinary Perspective

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Featuring many examples of team science in practice within two Centers in particular:

STEPS
Science and Technologies for Phosphorus Sustainability

CENT
Center for the Environmental Implications of NanoTechnology

Wednesday, May 30th, 2024
National Academies
Research and Application in Team Science

Interdisciplinary Team Science for the purpose of CONVERGENCE

"While convergence and interdisciplinary research are closely allied, convergence is different because it goes beyond collaboration: **Convergence is the integration of historically distinct disciplines and technologies into a unified whole that creates fundamentally new opportunities**…"

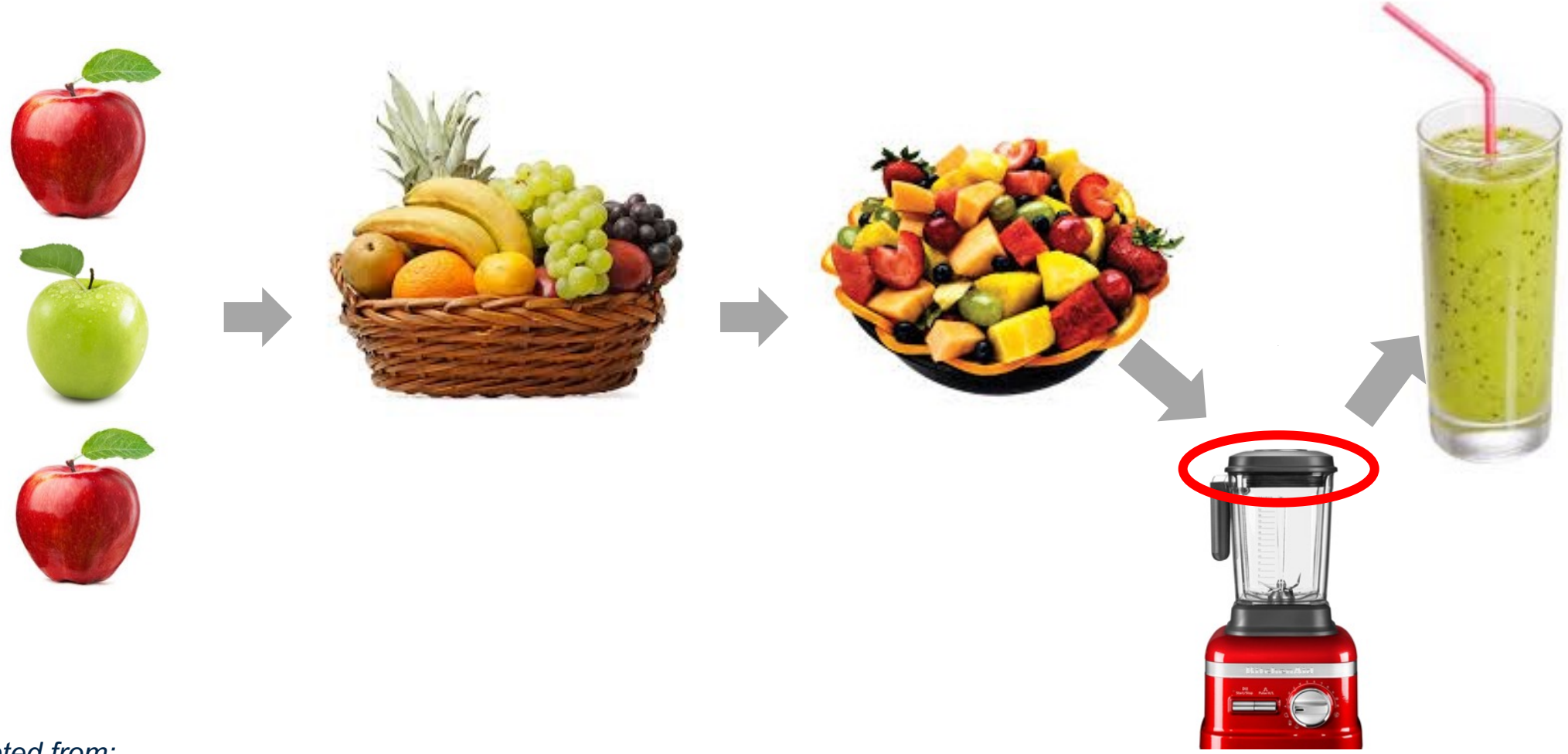
<u>Found in a footnote:</u>

"It should be noted that given the newness of the Convergence Research literature, most of our references are to the antecedents of Convergence Research."

Our first goal is to create those antecedent conditions!

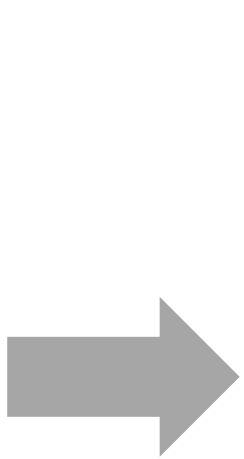
Many flavors of integration

Disciplinary **Multidisciplinary** **Interdisciplinary** **Transdisciplinary**



Analogy adapted from:
Moti Nissani, Fruits, Salads, and Smoothies: A Working Definition of Interdisciplinarity. The Journal of Educational Thought (JET) / Revue de la Pensee Educative. Vol. 29, No. 2 (August 1995), pp. 121-128

How, practically, do we make this real?



INTEGRATION OBJECTIVES & ACTIVITIES

1

Generate resources and provide training to build convergence capacity in teams:

Create tools, develop and manage convergence boundary objects, and design and facilitate intersectional events that bring people together across boundaries to create new knowledge.

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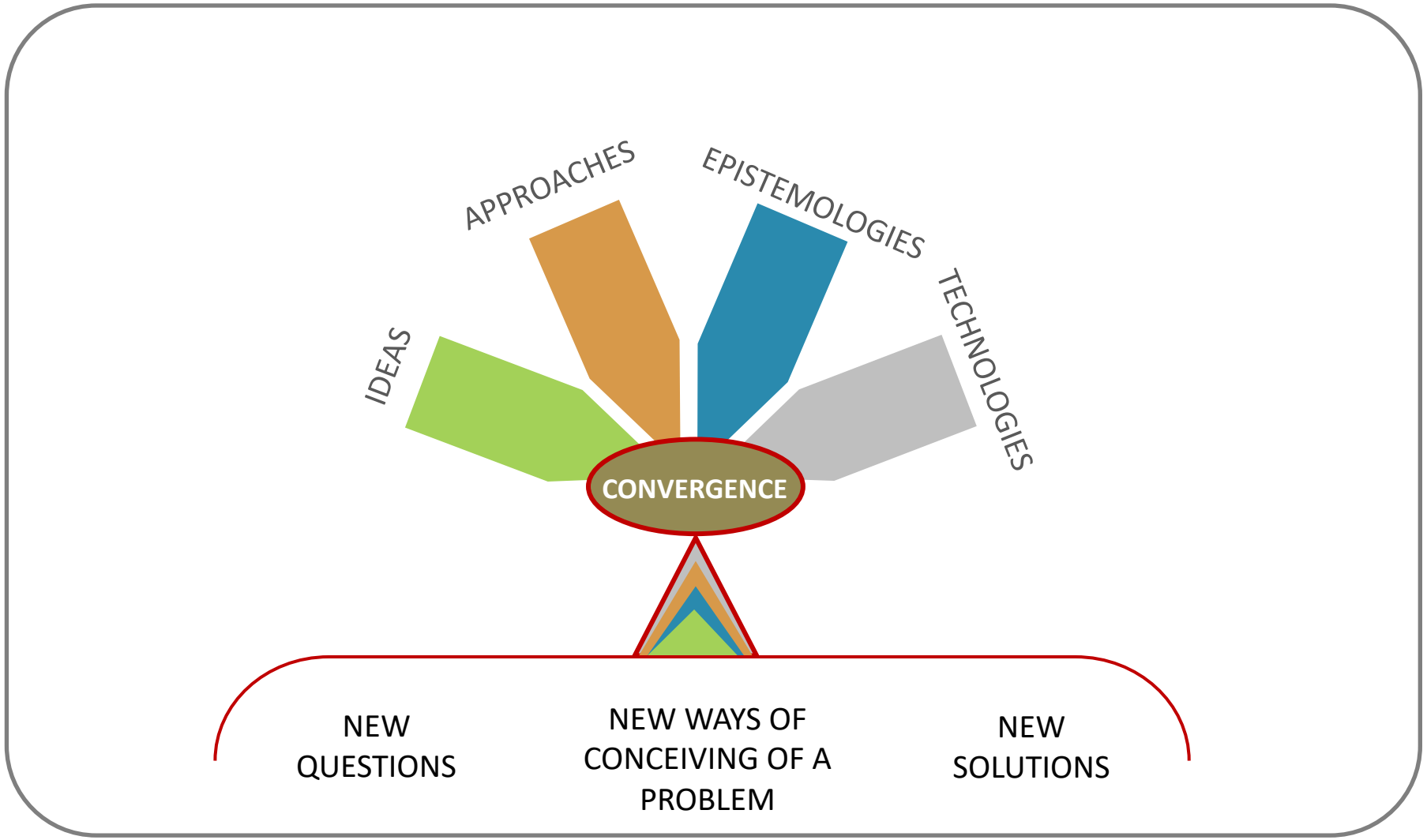
What is CONVERGENCE?



Slide courtesy of Christine Ogilvie Hendren

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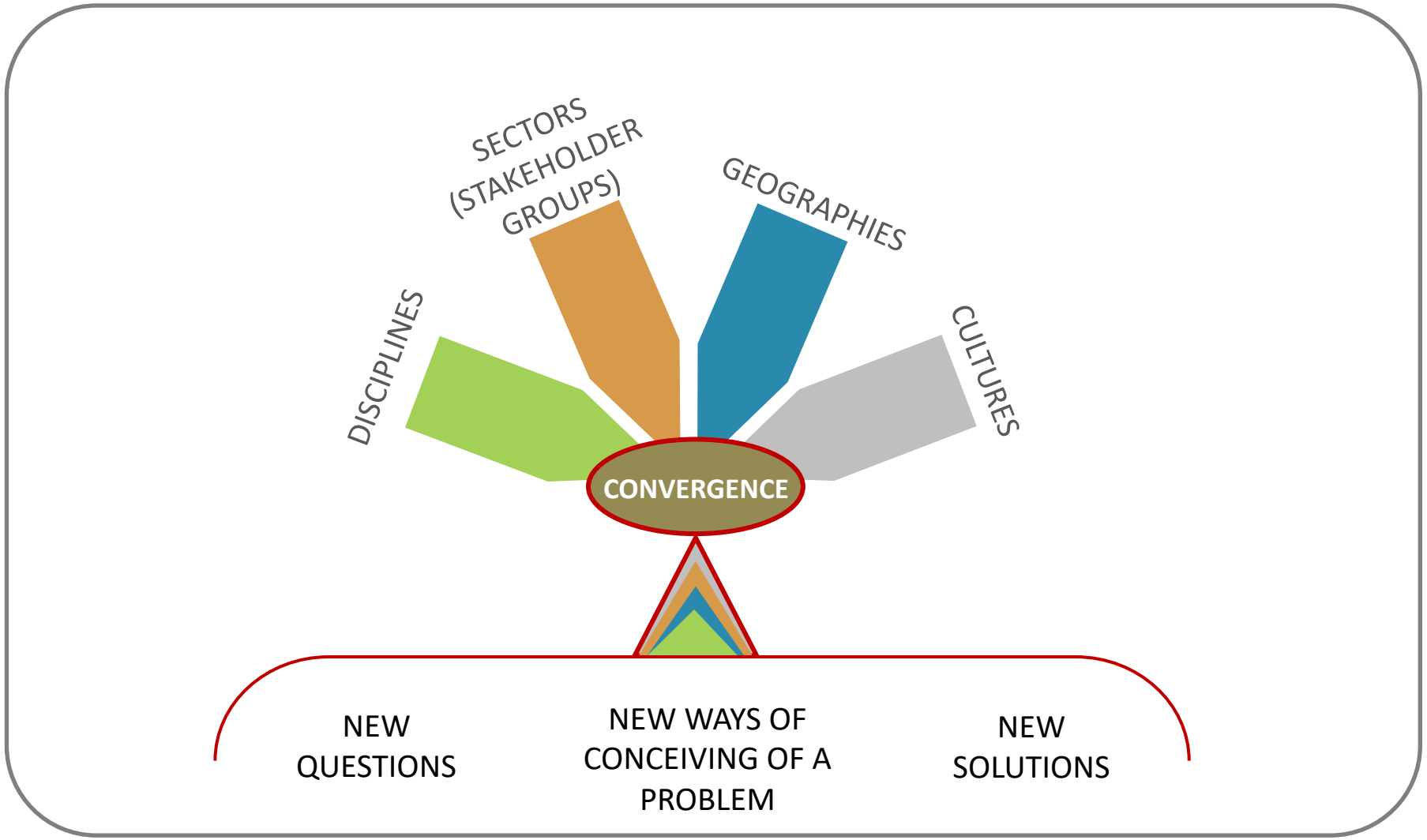
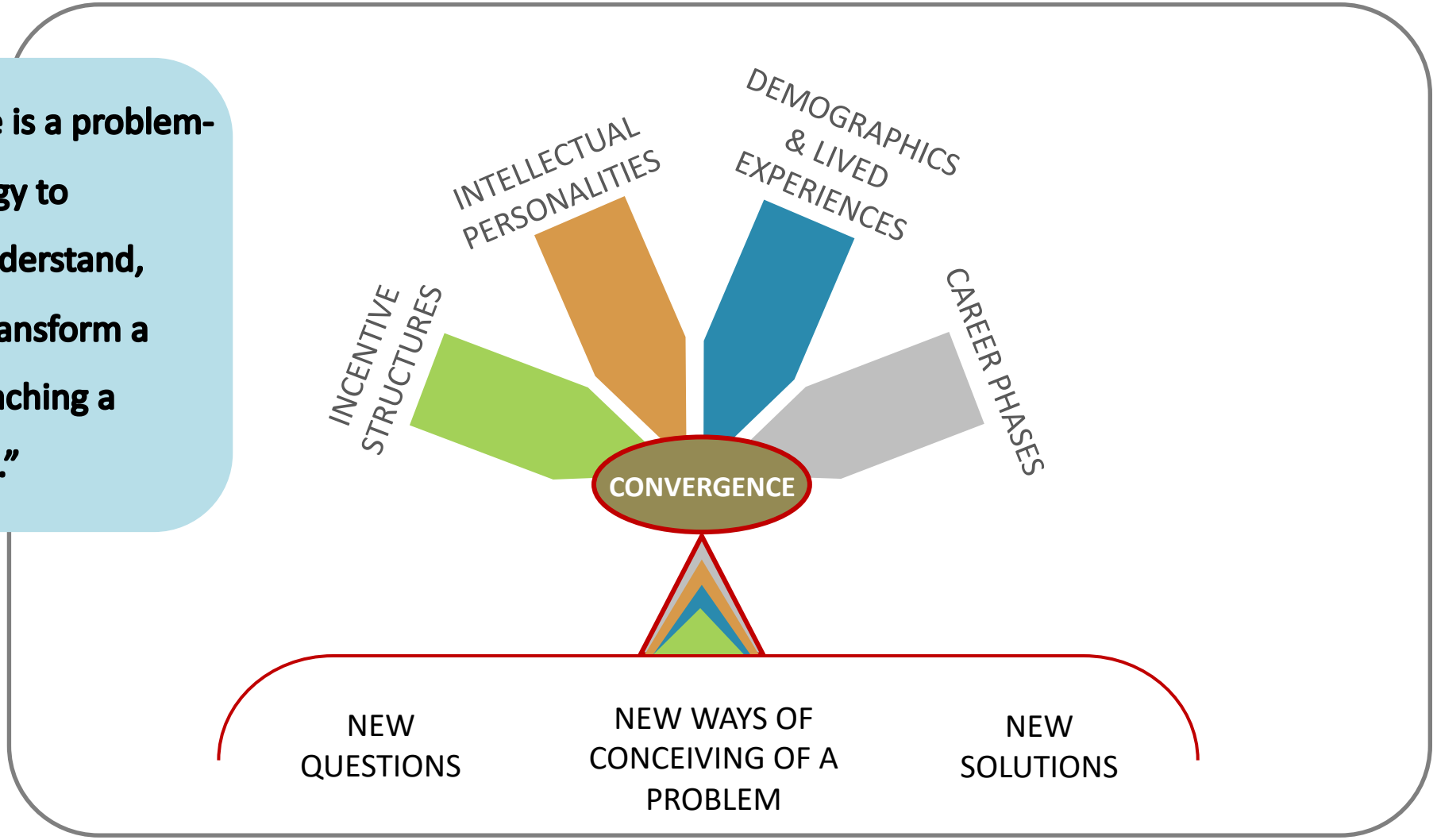


Slide courtesy of Christine Ogilvie Hendren

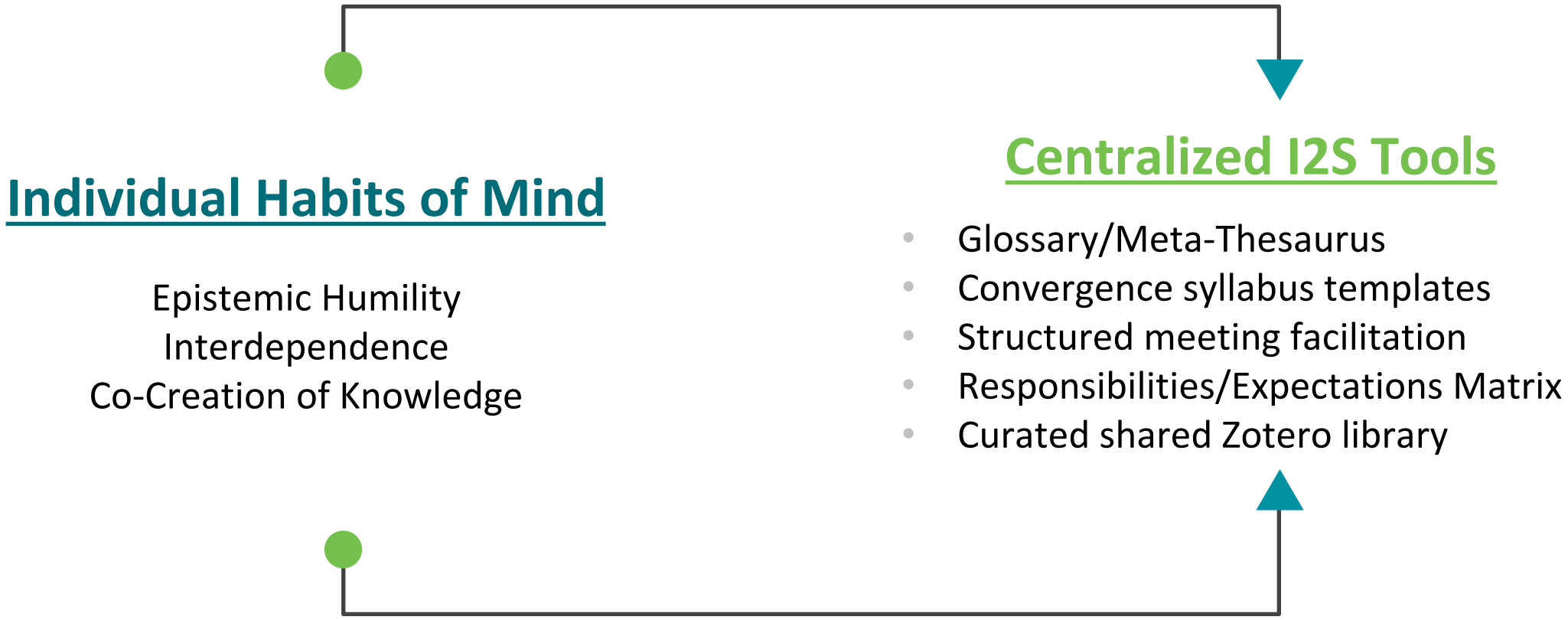
What is CONVERGENCE?

"Convergence is a problem-solving strategy to holistically understand, create, and transform a system for reaching a common goal."



Roco, 2020. "Principles of convergence in nature and society and their application: from nanoscale, digits, and logic steps to global progress"

Capacity Building to Navigate Convergence



Toolkit Highlight: Individual Habits of Mind

Epistemic Humility

- Recognition of reliance on others' expertise to understand
- Recognition that on certain topics, no confidence is possible
- A keen awareness of our vulnerability to error

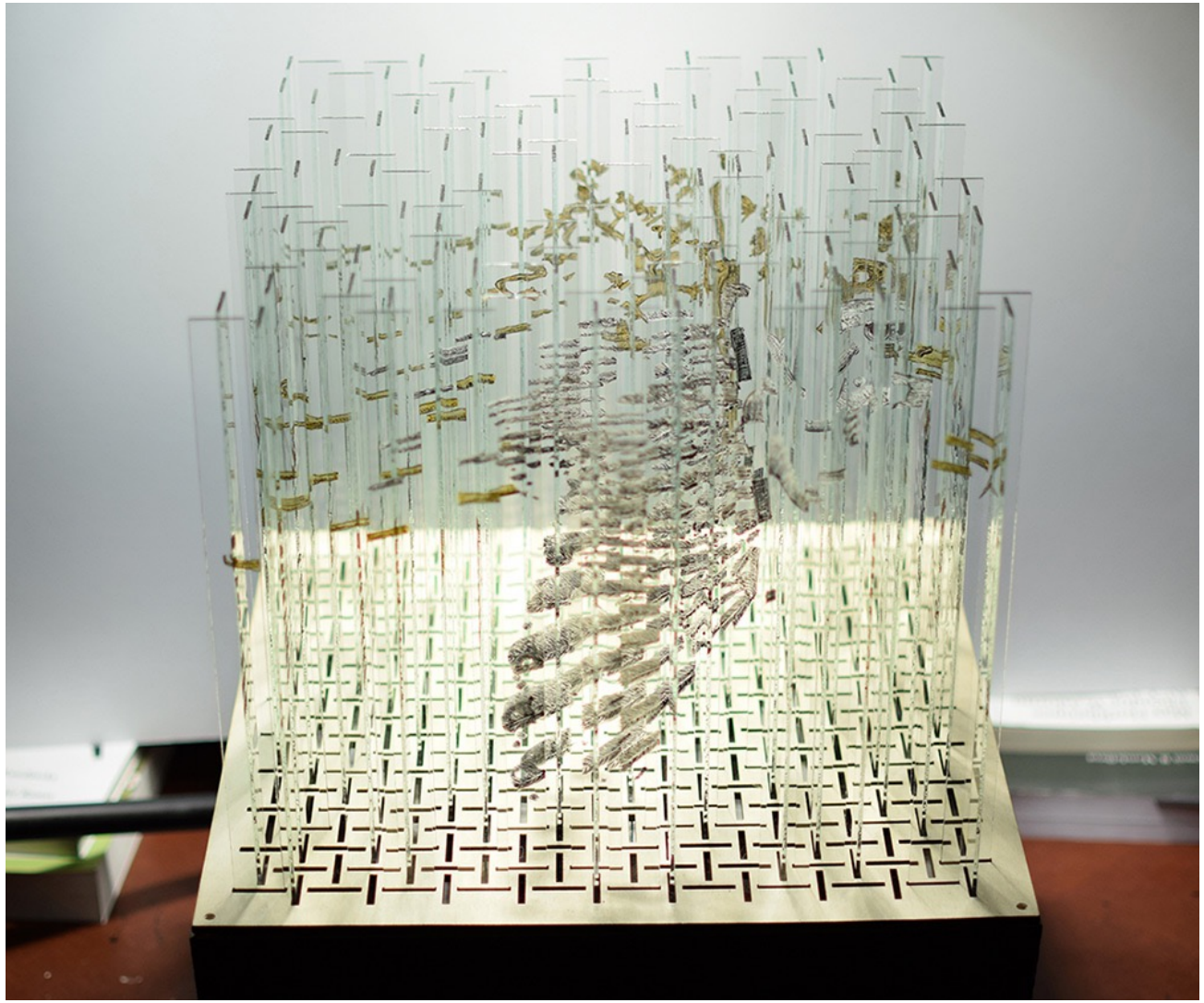
Interdependence

- All aspects of both natural and human activity systems constitute a holistic unit
- Team culture of connectivity and synergy coheres individual processes through network structuring and trust

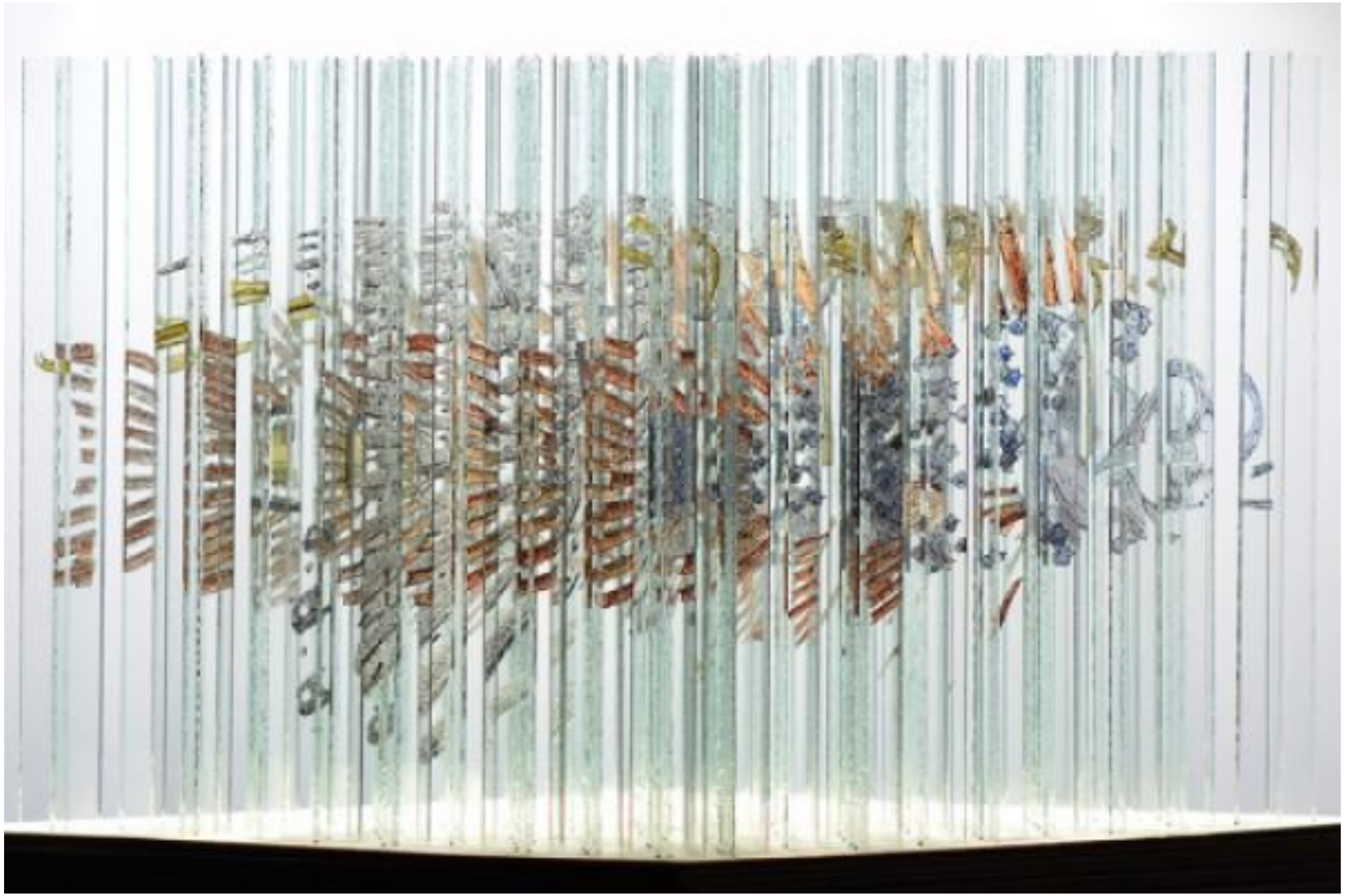
Co-Creation of Knowledge

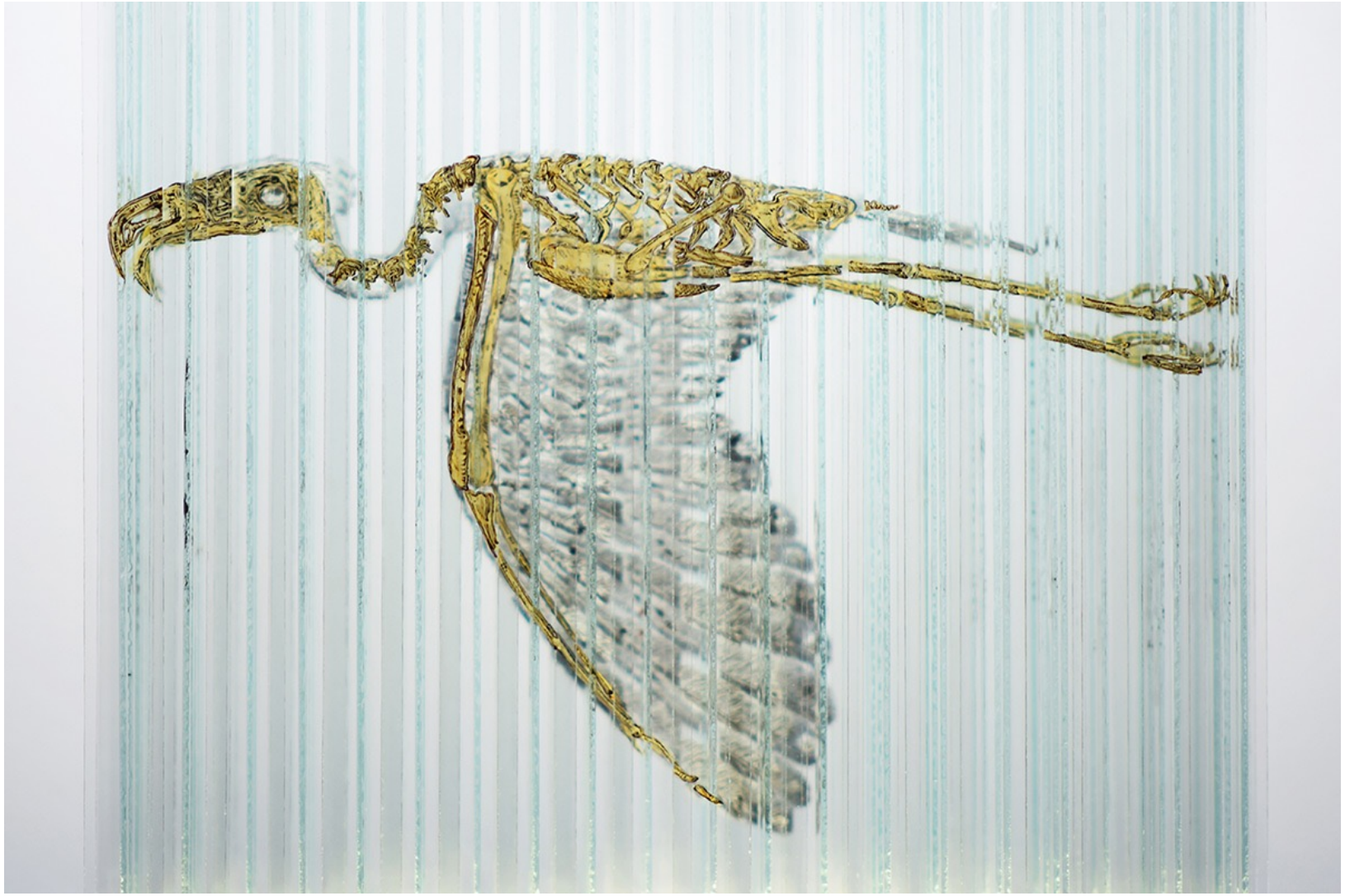
- Working on problems in applied contexts to stimulate interactions between fields
- Inviting non-academic stakeholders to equal agency in agenda-setting
- Seeking contextual rather than reductionist approach to discovery

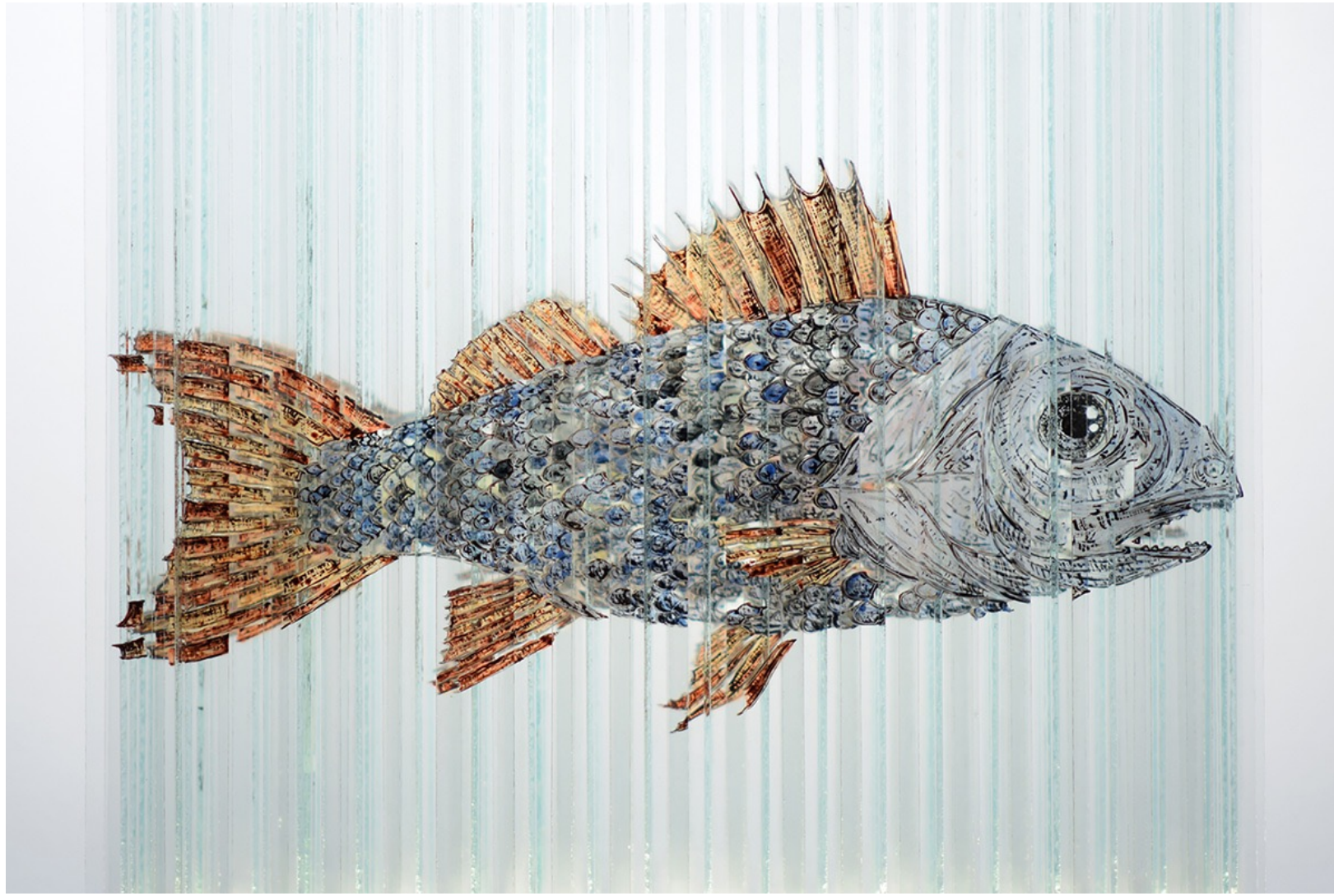
Roco, Mihail 2015. Principles and Methods that Facilitate Convergence. Handbook of Science and Technology Convergence DOI 10.1007/978-3-319-04033-2_2-2

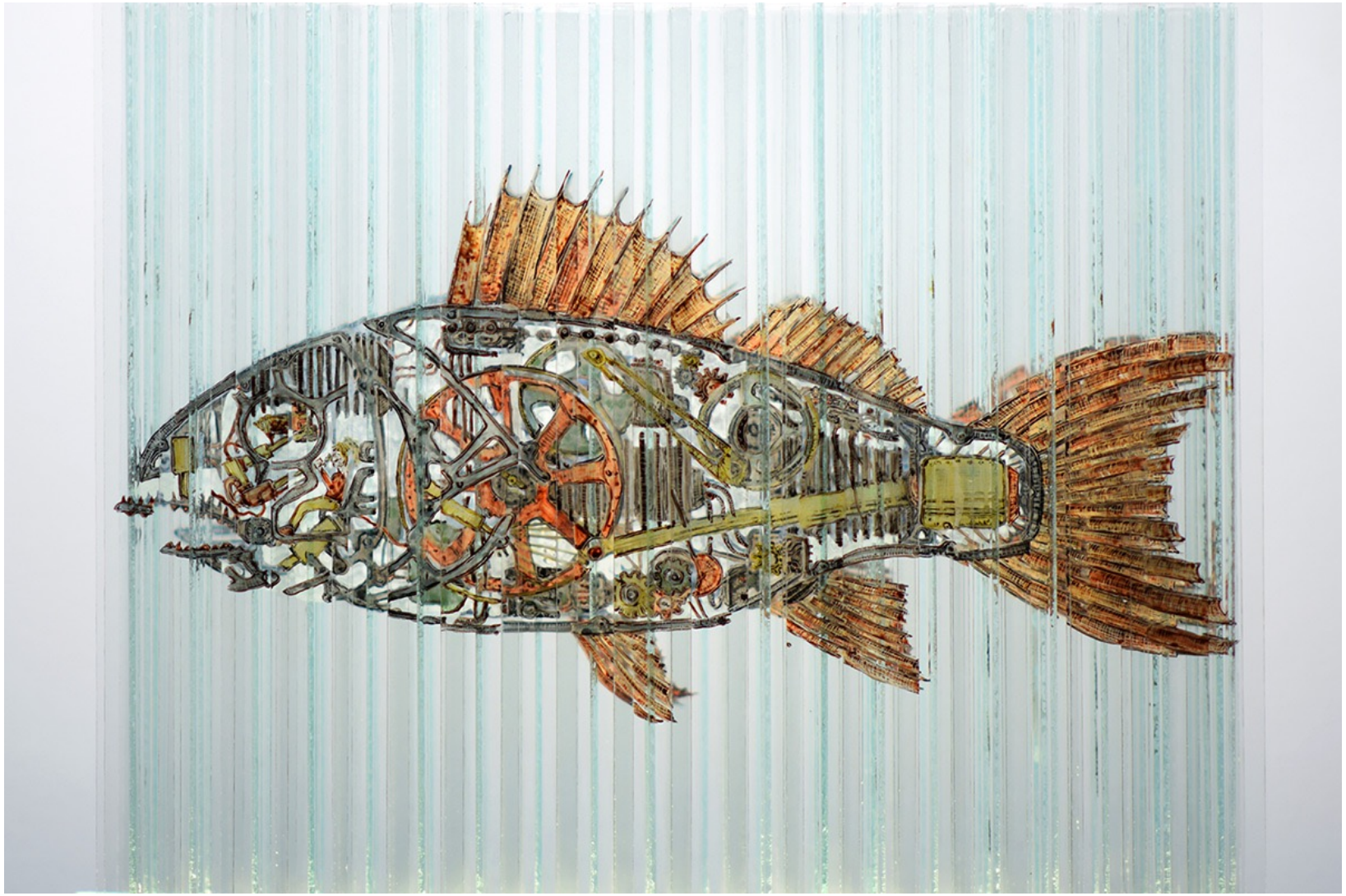


Emulsifer, by Thomas Medicus









Boundary Object Creation & Management

What is a Boundary Object?

- An artifact – abstract or concrete – that people coming from a range of knowledge bases can engage with to address a problem together
- Allows a broad range of individuals to contextualize their contributions to a highly complex problem.

The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds."

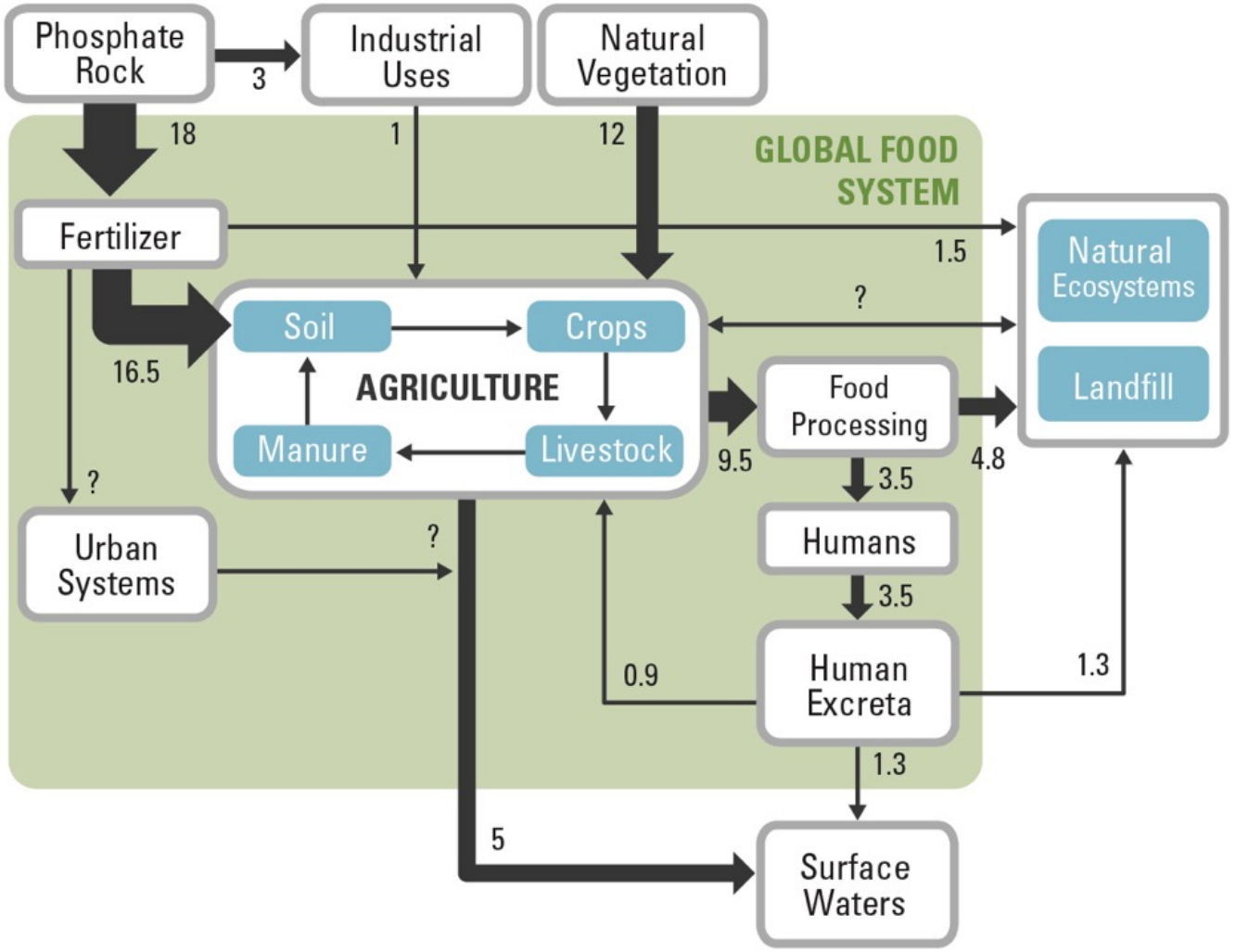
Susan Leigh Star (1989 & 2010) - Science, Technology and Society, Computer and Information Science, Social Ecology, and Library Sciences

Boundary Object Creation & Management

Diagrams & Conceptual Maps
Interactions

Integrated Language and Data
Processes

Physical Experiment Spaces



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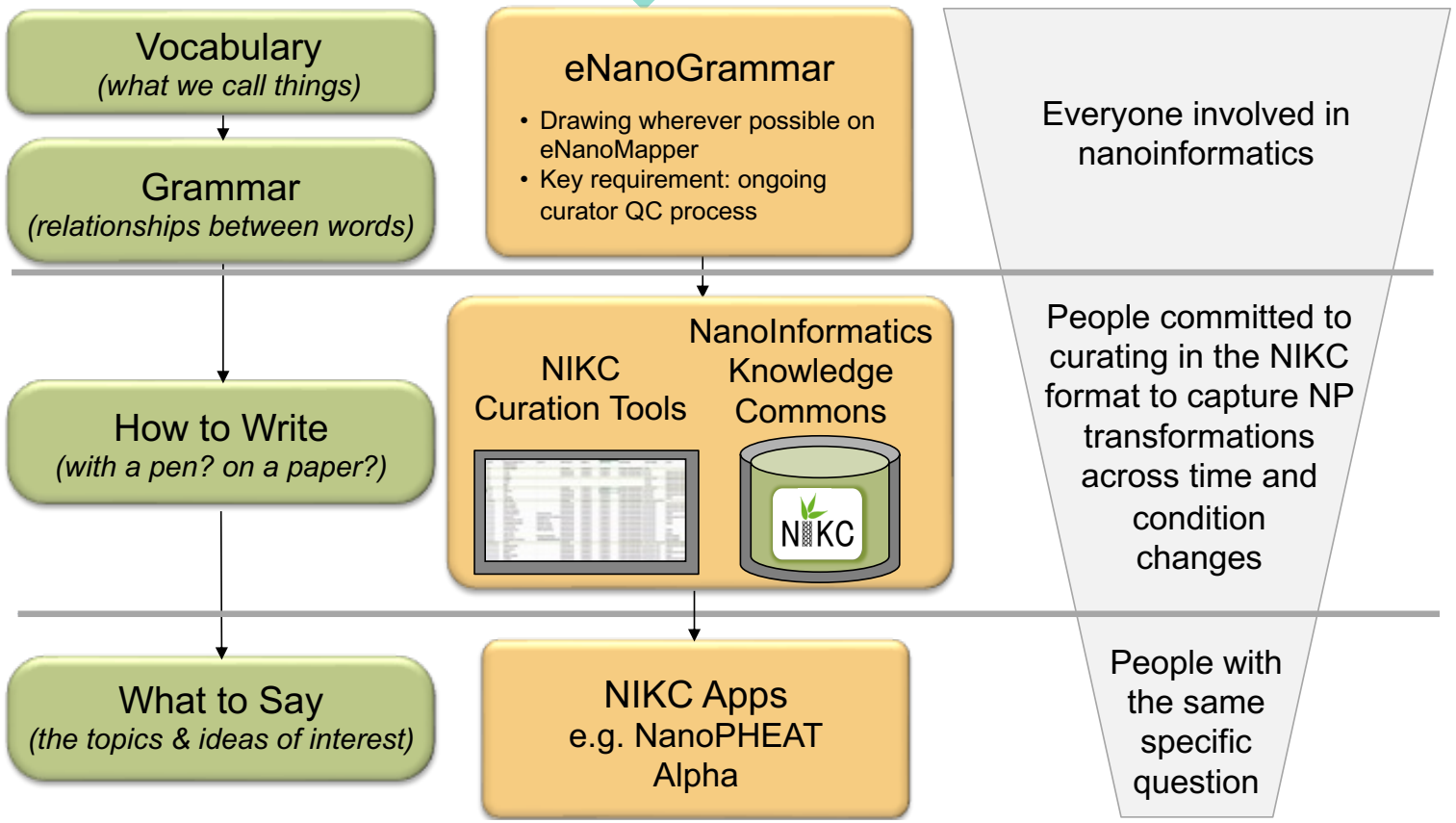
Language and data integration schema for United States and European Nanomaterial Environmental Data harmonization



Boundary Object Creation & Management

Diagrams & Conceptua
Interactions

Physical Experiment Spaces

Ecologists
Microbiologists
Colloid scientists
Biogeochemists
Soil scientists
Analytical chemists

Integration Leadership Responsibilities in Interdisciplinary Research Teams

How Do We Ensure "More" Means Better, Not Harder?

Create consistent & efficient interactions	Lower planning lift for targeted knowledge exchange; consistent meeting times, formats, agendas
Tailor the "depth" of convergence	The level of fluency required in other disciplines will be student and project-dependent
Manage burdens of uncertainty	Name knowledge uncertainty (controllable & predictable) vs. inherent uncertainty (uncontrollable & unpredictable)
Create trainee exposure to decision processes	Provide access to systems level decision discussions between faculty and stakeholders

WEEKLY WEBINAR SERIES

Forging Team-wide relationships, enabling broad growth goals

Week 1

Visiting research seminar speakers, broadcast from host university

Experts across broad array of domains and sectors will visit and present work related to phosphorus sustainability.

Week 2

Building convergence capacity

e.g. convergence toolkit presentations, career guidance, mental health support, strengths assessments

Week 3

STEPS Trainee focus session

Planned and hosted by Students: Early phase students share approaches and plans as status updates; later phase students take turns giving talks for mentoring and feedback from across STEPS

Week 4

Non-academic stakeholder integration

Invite feedback non-university partners, e.g. stakeholder groups, TBL site representatives

Co-Creating Explicit Expectations

1. Tools exist to support successful collaboration and team science by setting expectations, preventing / managing conflict, and planning for success in team science.

2. Intentional integration planning can improve team function, individual satisfaction, and strongly impact research and educational outputs.

3. STEPS continues commitment to onboarding this knowledge as we launch.

- "Welcome to my team" letter
- Pre-nup for Scientists
- Operations Manuals
- NIH-published Comprehensive Collaboration Planning[1]

1. Rationale for Team Approach and Configuration
2. Collaboration Readiness
3. Technological Readiness
4. Team Functioning
5. Communication & Coordination
6. Leadership, Management & Administration
7. Conflict Prevention & Management
8. Training
9. Quality Improvement Activities
10. Budget & Resource Allocation

Hall, K.L., Vogel, A.L. and Crowston, K., 2019. Comprehensive collaboration plans: practical considerations spanning across individual collaborators to institutional supports. In Strategies for Team Science Success (pp. 587-612). Springer.

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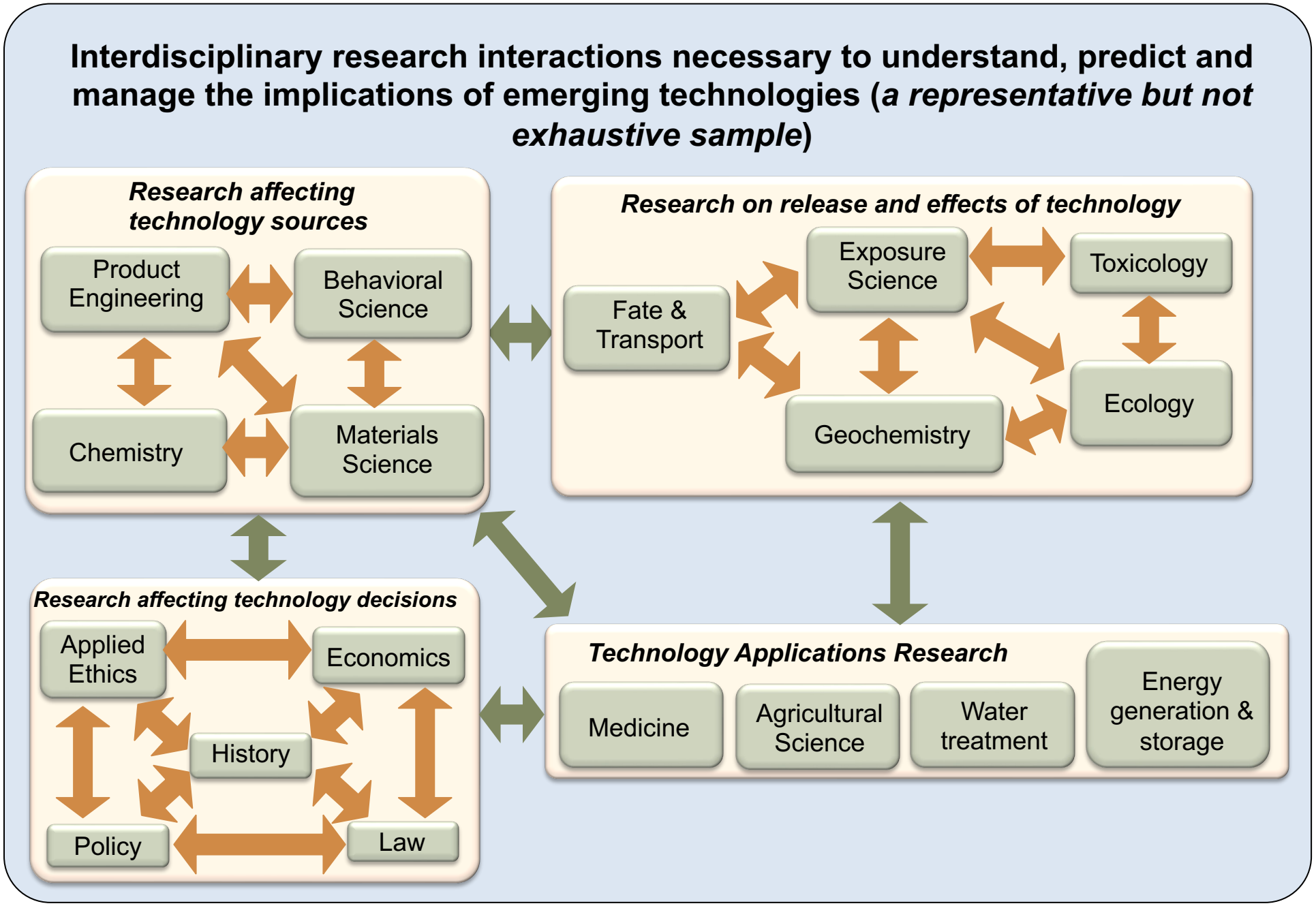
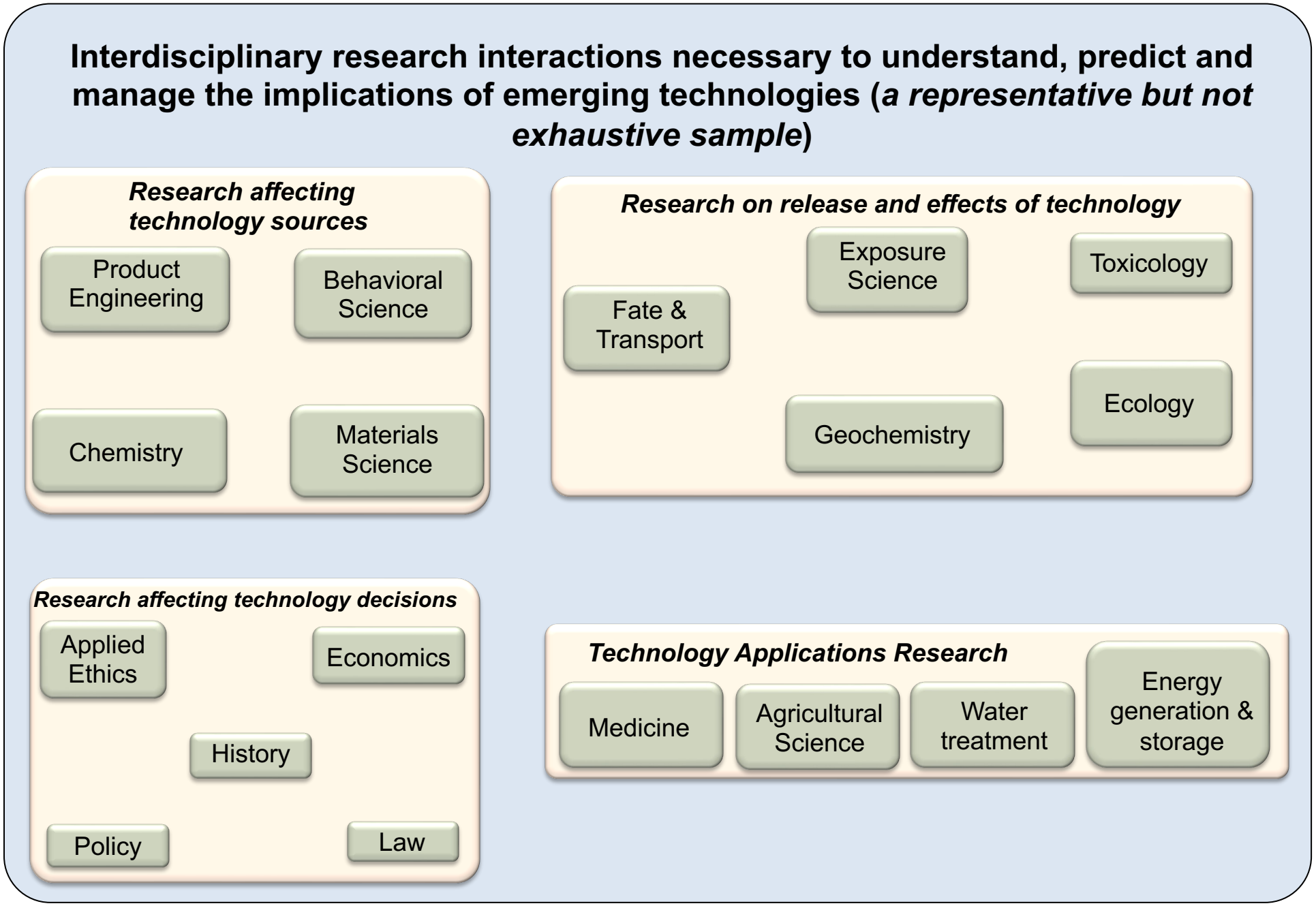

Interdisciplinary research interactions necessary to understand, predict and manage the implications of emerging technologies (a representative but not exhaustive sample)
Research affecting technology sources
Product Engineering
Behavioral Science
Chemistry
Materials Science
Research on release and effects of technology
Fate & Transport
Exposure Science
Toxicology
Geochemistry
Ecology
Research affecting technology decisions
Applied Ethics
Economics
History
Policy
Law
Technology Applications Research
Medicine
Agricultural Science
Water treatment
Energy generation & storage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Applied Ethics
Economics
History
Policy
Law
Technology Applications Research
Medicine
Agricultural Science
Water treatment
Energy generation & storage

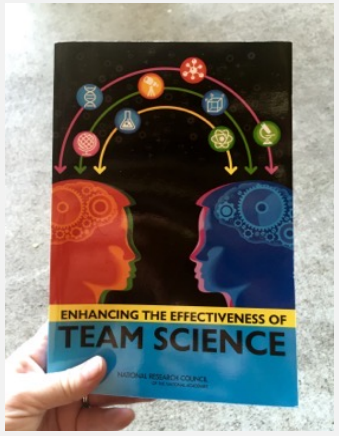
Be the arrow

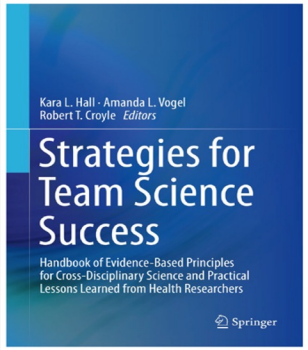
Eureka – someone must be the arrow!

Drawing on the Science of Team Science (SciTS) and Integration and Implementation Sciences (I2S)

INSciTS | Building the knowledge base for effective team science

International Network for the Science of Team Science

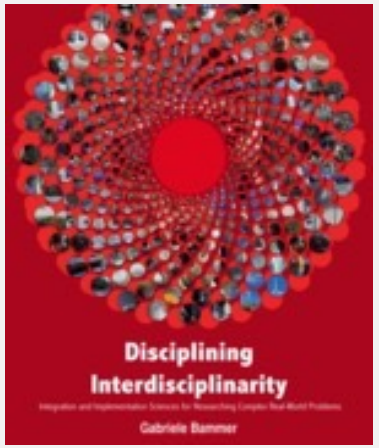




INTEGRATION AND IMPLEMENTATION SCIENCE (I2S)

Research resources for understanding and acting on complex real-world problems

Dr. Gabriele Bammer



An intellectual community of practice for "arrows"

Interdisciplinary Integration Research Careers Hub

A community of practice, est. 2016

- Understand roles
- Compare language & experiences
- Share strategies
- Draw on team science literature

Developing the Profession

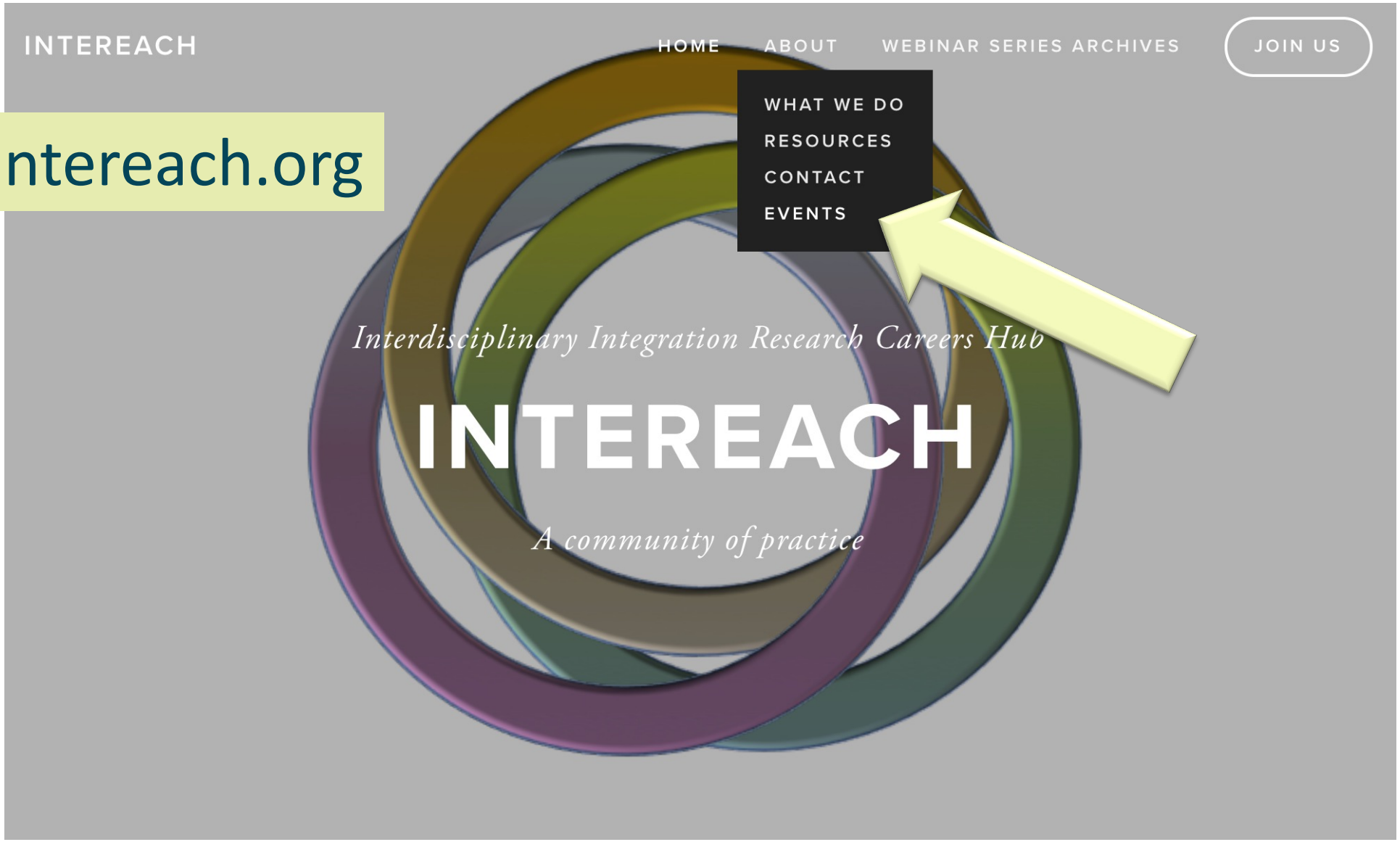
Making the case for institutionalizing intereach roles and career paths.

Dual Mission

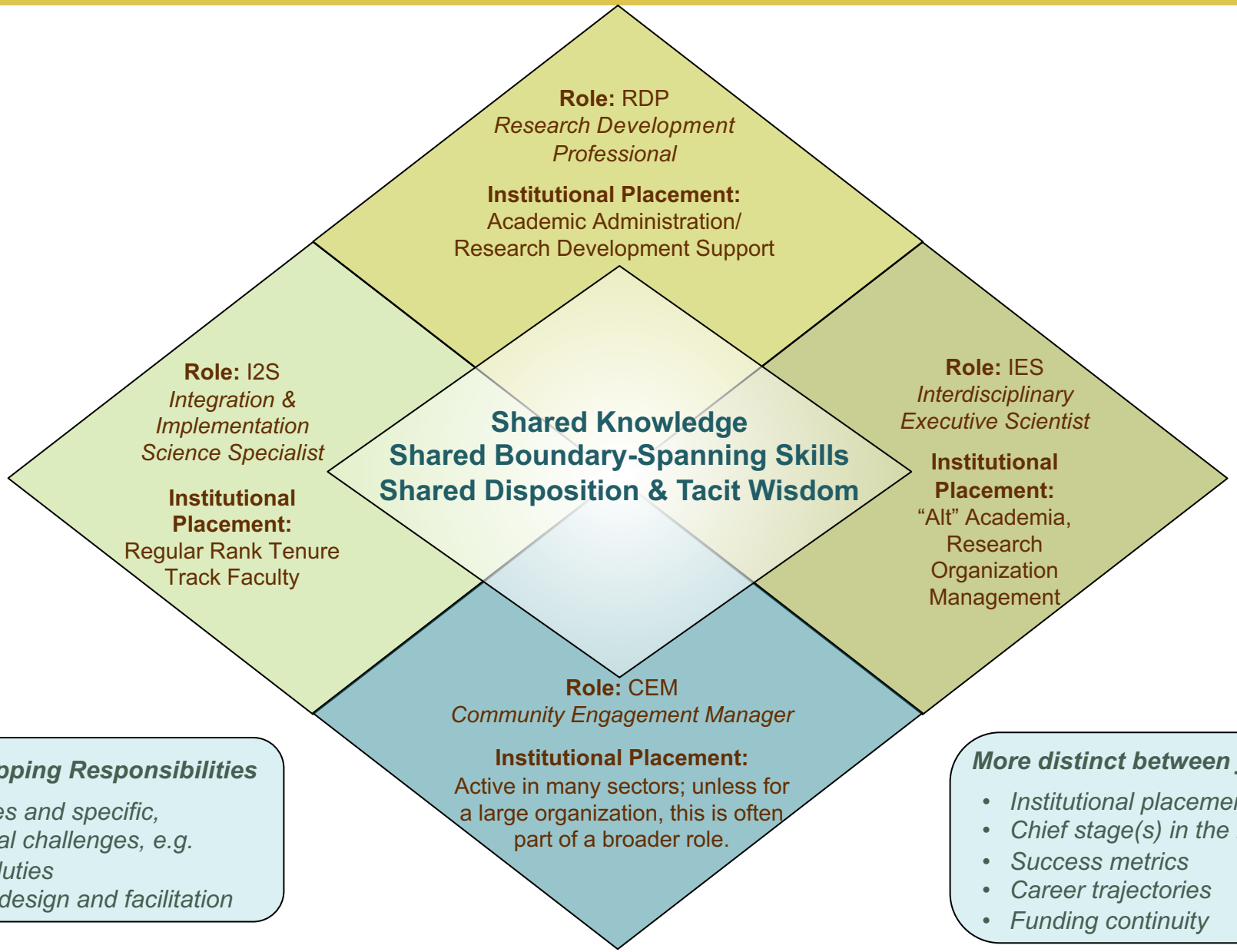
Professional Development

Develop professional training and educational resources.

www.intereach.org



Overlaps & Distinctions in Integration Practitioner Jobs



Many Overlapping Responsibilities

- *Job activities and specific, transactional challenges, e.g.*
  - *Budget duties*
  - *Meeting design and facilitation*

More distinct between job types

- *Institutional placement*
- *Chief stage(s) in the research life cycle*
- *Success metrics*
- *Career trajectories*
- *Funding continuity*

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WORK BACKWARDS FROM VISION TO CREATE CONVERGENT CONDITIONS

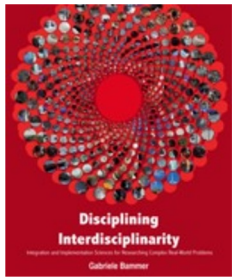
STEPS
Science and Technologies for Phosphorus Sustainability

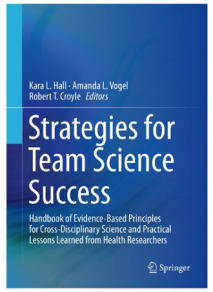
- Education researcher
- 2 Social Scientists
- 1 Historian
- 2 Engineer/I2S post-docs
- 1 I2S co-PI

Harness Team Science & Transdisciplinary Research & Praxis

INTEREACH — *Interdisciplinary Integration Research Careers Hub*

INSciTS-International Network for the Science of Team Science





Antecedent conditions for collaboration in teams

Foster and track immediately

Interim Milestones

Signs that we're on the right track?

Successful convergent research outcomes

Convergent research and education outcomes emerge later

Ask: WHAT KIND OF CULTURE IS FERTILE SOIL FOR CONVERGENCE?

Antecedent conditions for collaboration in teams

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Interim Milestones

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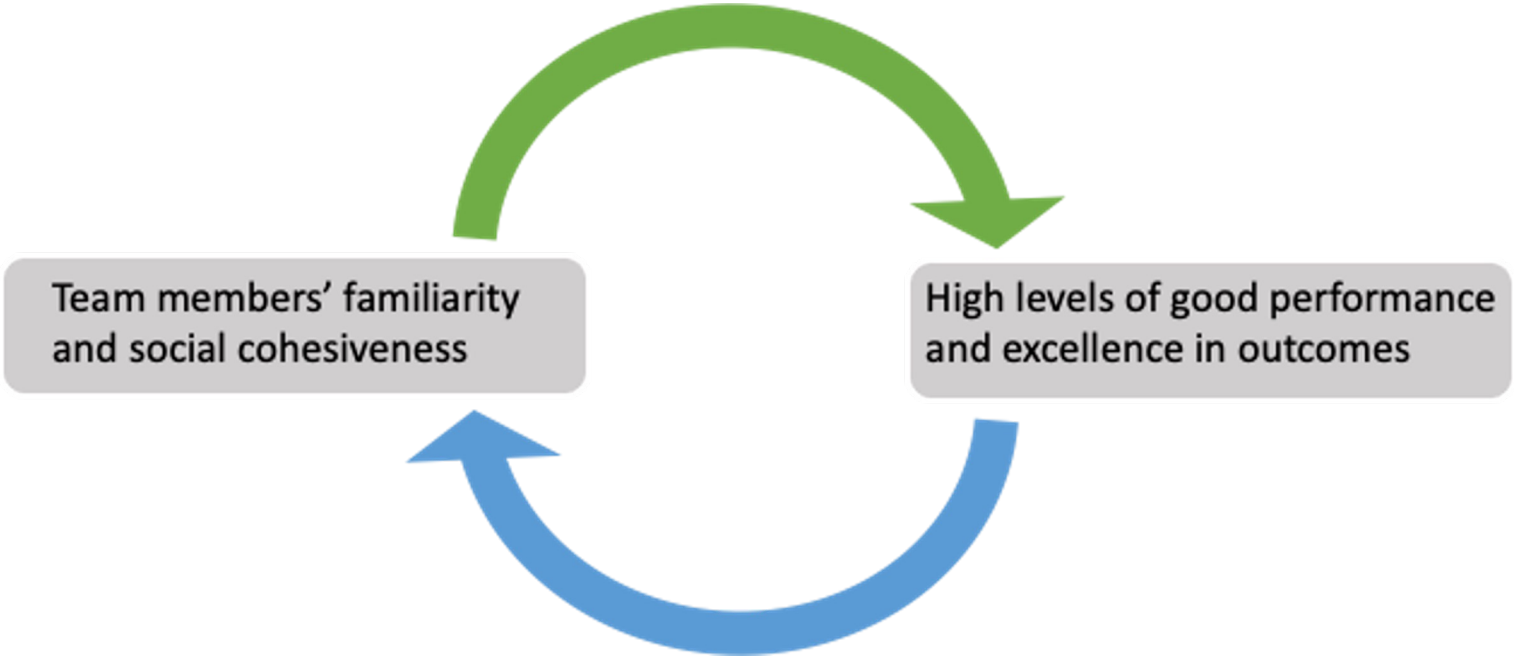
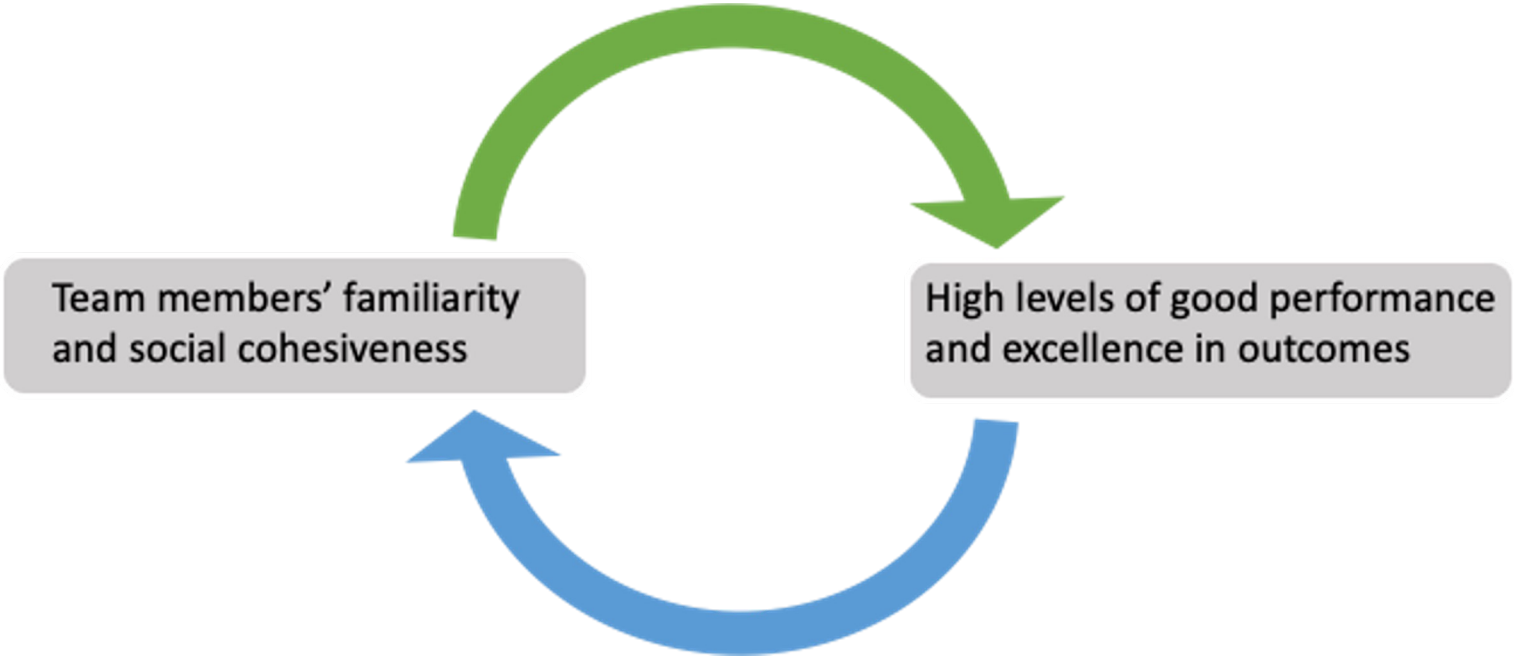
REINFORCING LOOP: SOCIAL COHESION & HIGH PERFORMANCE



From social psychology and management research:
Team effectiveness in reaching collective goals is found to be positively impacted by two mutually reinforcing factors – *either one of them alone leads to a flattening or decrease in success over time*.

Stokols, D., Misra, S., Moser, R.P., Hall, K.L. and Taylor, B.K., 2008. The ecology of team science: understanding contextual influences on transdisciplinary collaboration. *American journal of preventive medicine*, *35*(2), pp.S96-S115.
Kerr, N.L. and Tindale, R.S., 2004. Group performance and decision making. Annu. Rev. Psychol., 55, pp.623-655.

CREATE ANTECEDENT CONDITIONS FOR MUTUAL REINFORCEMENT



Emergent states → new sparks, more novel lightbulbs coming on

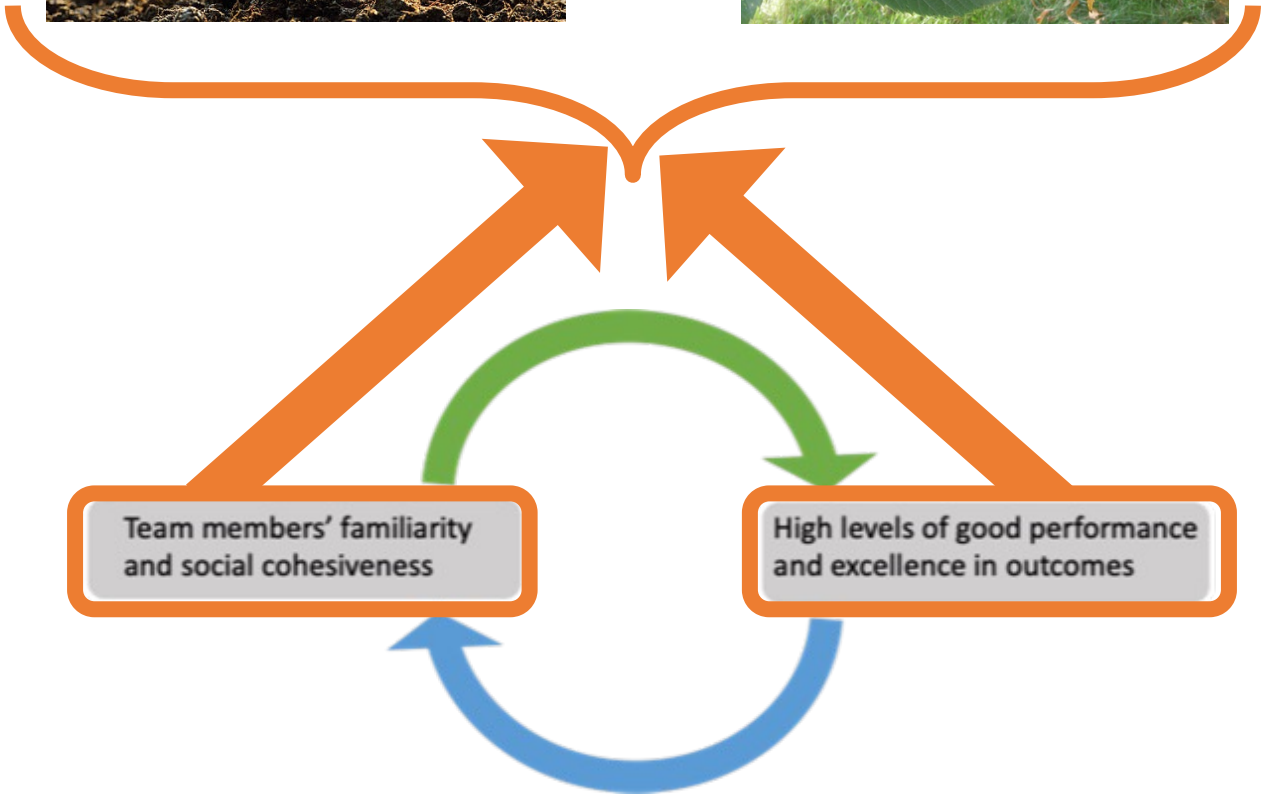
Diverse in multiple measures → many lenses, divergent lived experiences, different ways of thinking about problems

Adaptive teams → ready to seize opportunities and able to pivot

Psychological safety → need to be able to take risks, and it can't feel dangerous to do so

Productive accountability → celebrate wins, hold a high bar for ourselves, sharpen best ideas

WATCH FOR AND STUDY "SEEDLINGS" AND THREATS



Fostering emergent, adaptive, productive outcomes

How, practically, do we make this real?

1. **Use and teach methods**
2. **Hire and train integrators**

3. **Research to generate more methods**

1 Co-PI I2S
1 Managing Director I2S
3 Convergence Post-docs

STEPS
Science and Technologies for Phosphorus Sustainability

1 Executive Director I2S
1 Post-master turned PhD student

CENT


Thank you!
Questions?

Thank you to so many colleagues and sponsors!