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# Convergence Research Paradigm: Role for Engineering

ECEDHA Emerging  
Technologies Summit  
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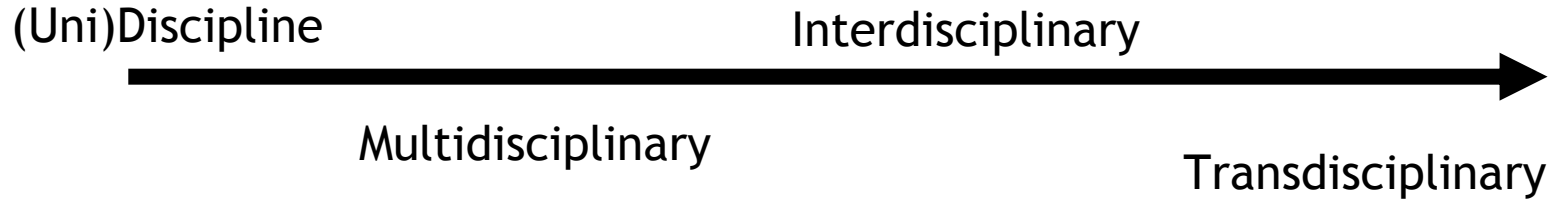
# Presentation dedicated to Kishan Baheti



# Outline

- Convergence
- Team Science
- Inclusion and Diversity
- Emerging Technologies
- Conclusions

# What is Convergence?



# 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

# Interdisciplinary

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

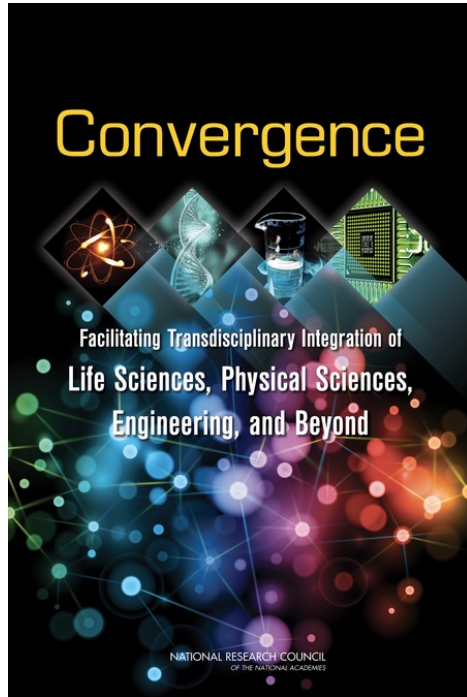
- Key defining concept: **integration**
- Individuals may work alone, but increasingly research is team-based.
- Collaboration introduces social integration, project management and communication.

# 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**.

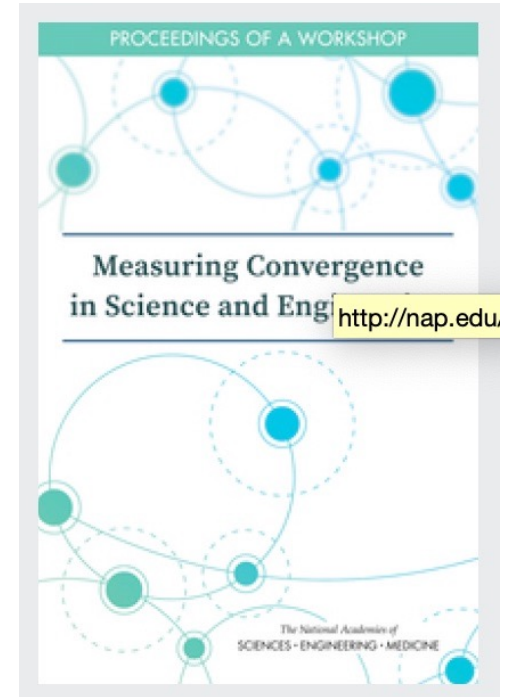
# Convergence Paradigm



[NRC 2014](#)



[MIT 2016](#)



[NASEM 2021](#)



# 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.

# 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 ...

# Four Key Pillars

- People
- Organization
- Culture
- Ecosystem

# People

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

# Organization

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

# Culture

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

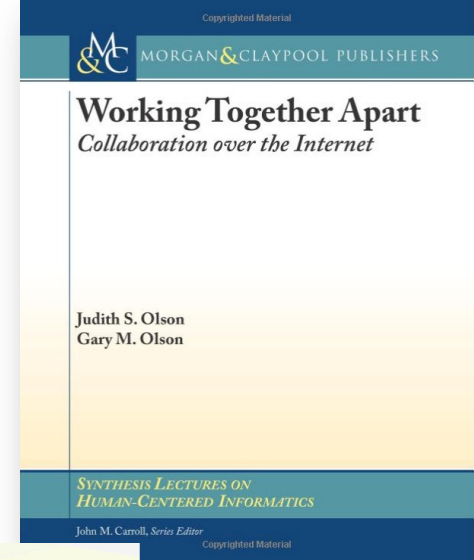
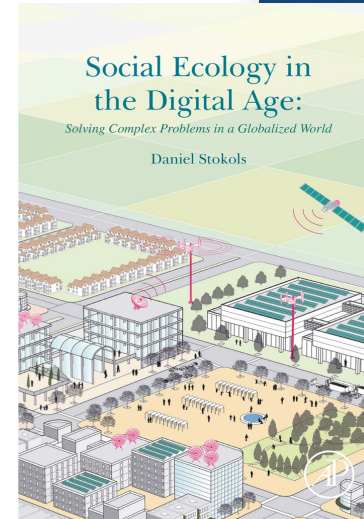
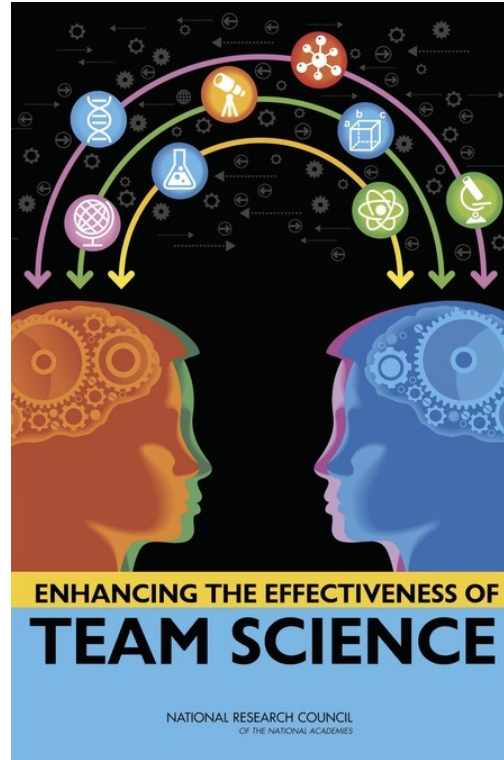
# Ecosystem

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

# Convergence and Team Research

## Collaboration & Team Science:

*A Field Guide*

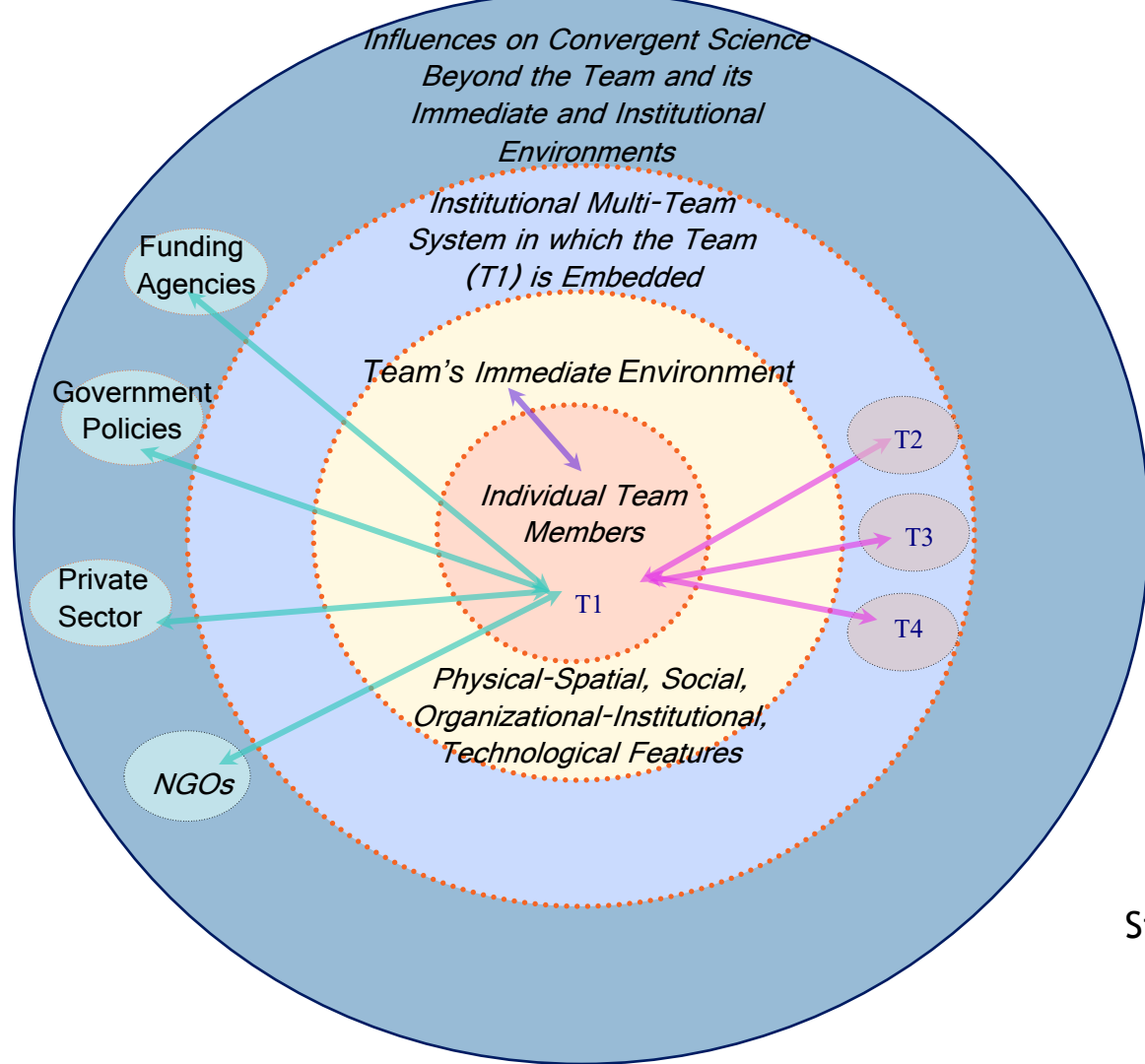




# Dimensions of Team Science

- 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. 2018)*



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

# Team Scholarship Accelerator Lab



TEAM SCHOLARSHIP ACCELERATION LAB

About

Team Resources



## Team Scholarship at UCI

<https://tsal.uci.edu/>

# 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 ....”

# 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

# **Innovation and Emerging Technologies**

# It is Getting Harder to Innovate

Figure 1: Aggregate Data on Growth and Research Effort

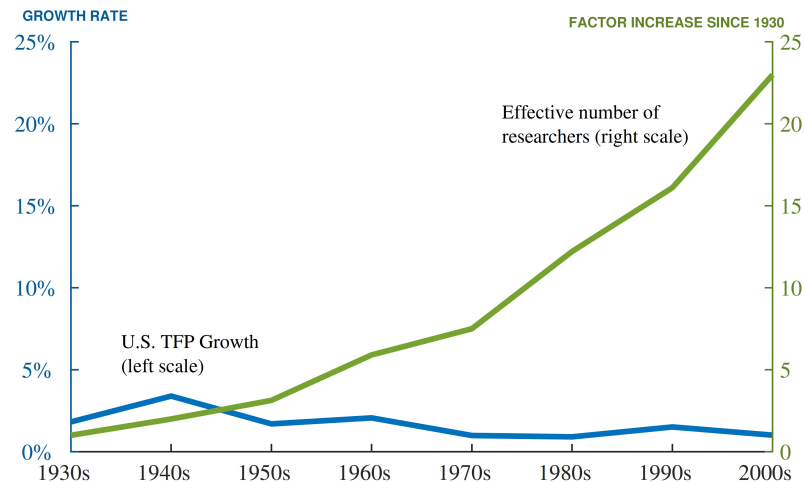
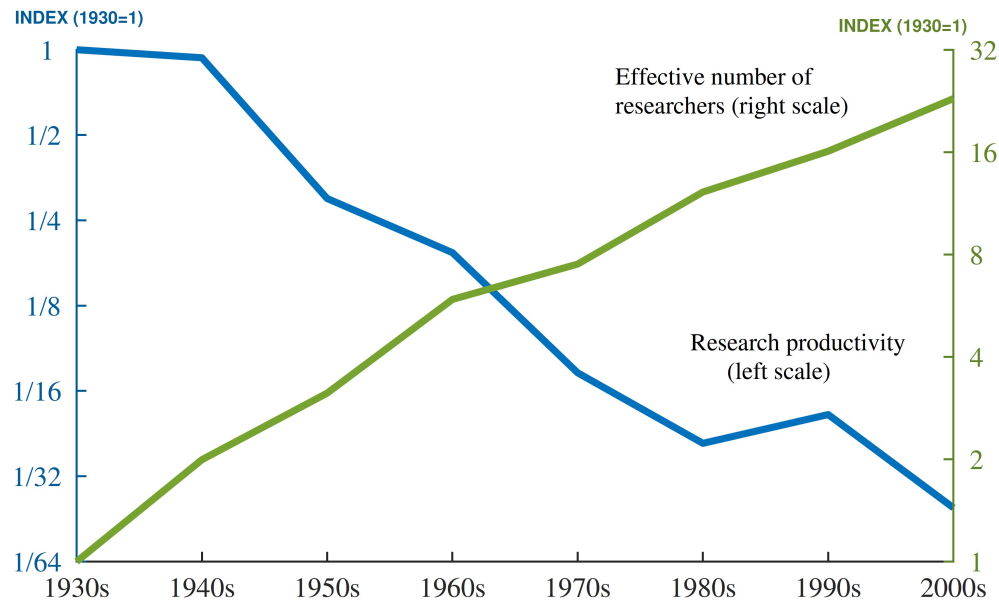


Figure 2: Aggregate Evidence on Research Productivity



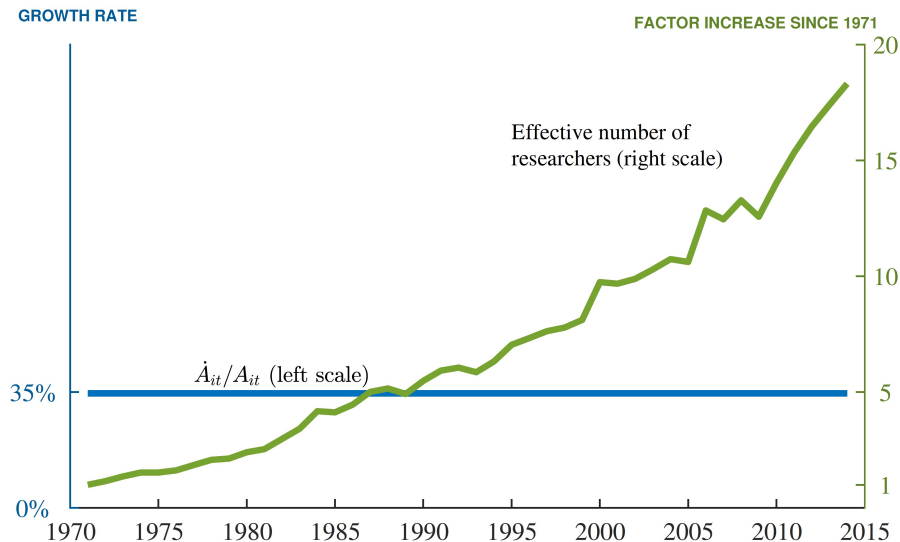
Note: Research productivity is the ratio of idea output, measured as TFP growth, to research effort. See notes to Figure 1 and the online data appendix. Both research productivity and research effort are normalized to the value of 1 in the 1930s.

Source: [Are Ideas Getting Harder to Come by, Bloom et al, 2020](#)



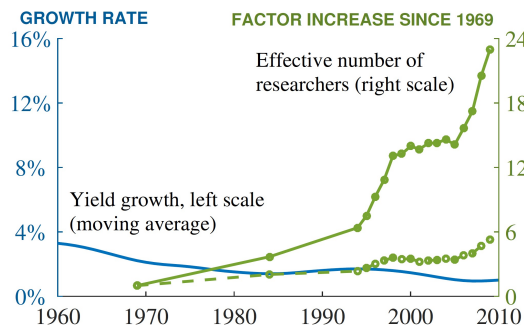
# Case of Semiconductor Technology

Figure 4: Data on Moore's Law

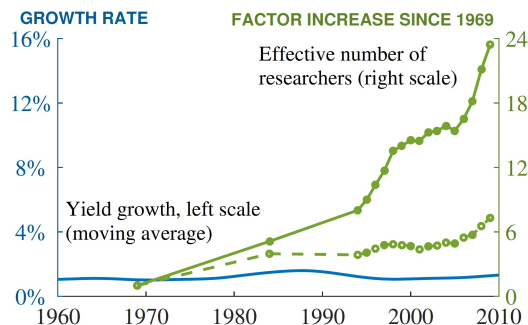


Note: The effective number of researchers is measured by deflating the nominal semiconductor R&D expenditures of key firms by the average wage of high-skilled workers. The R&D data includes research by Intel, Fairchild, National Semiconductor, Texas Instruments, Motorola, and more than two dozen other semiconductor firms and equipment manufacturers; see Table 1 for more details.

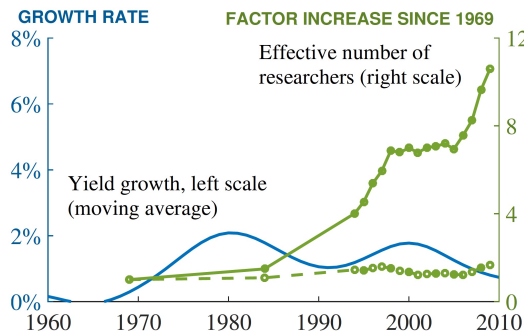
# Case of Agriculture Crops



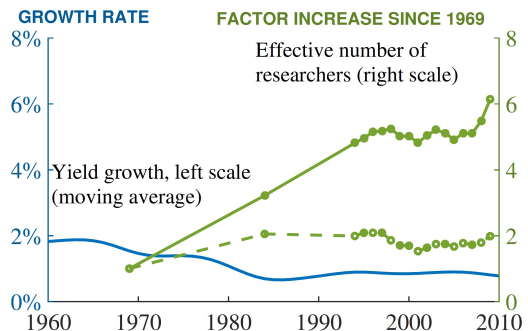
(a) Corn



(b) Soybeans

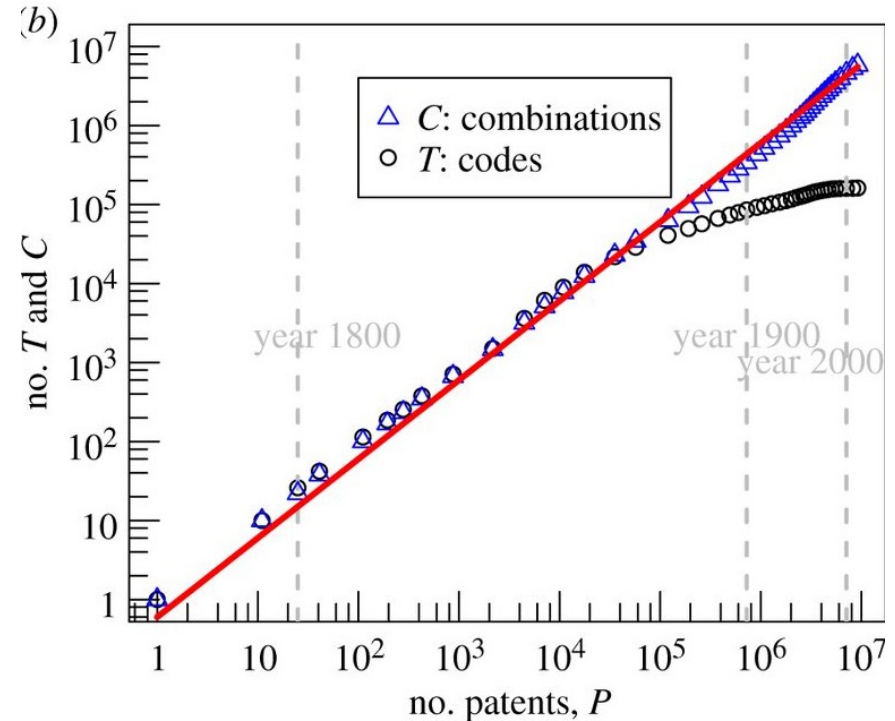
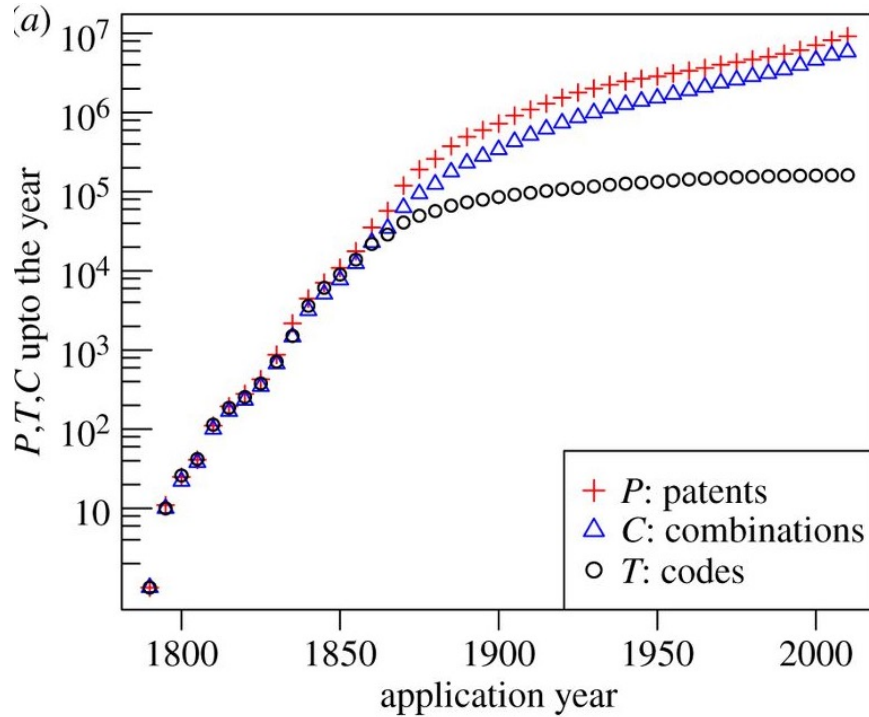


(c) Cotton

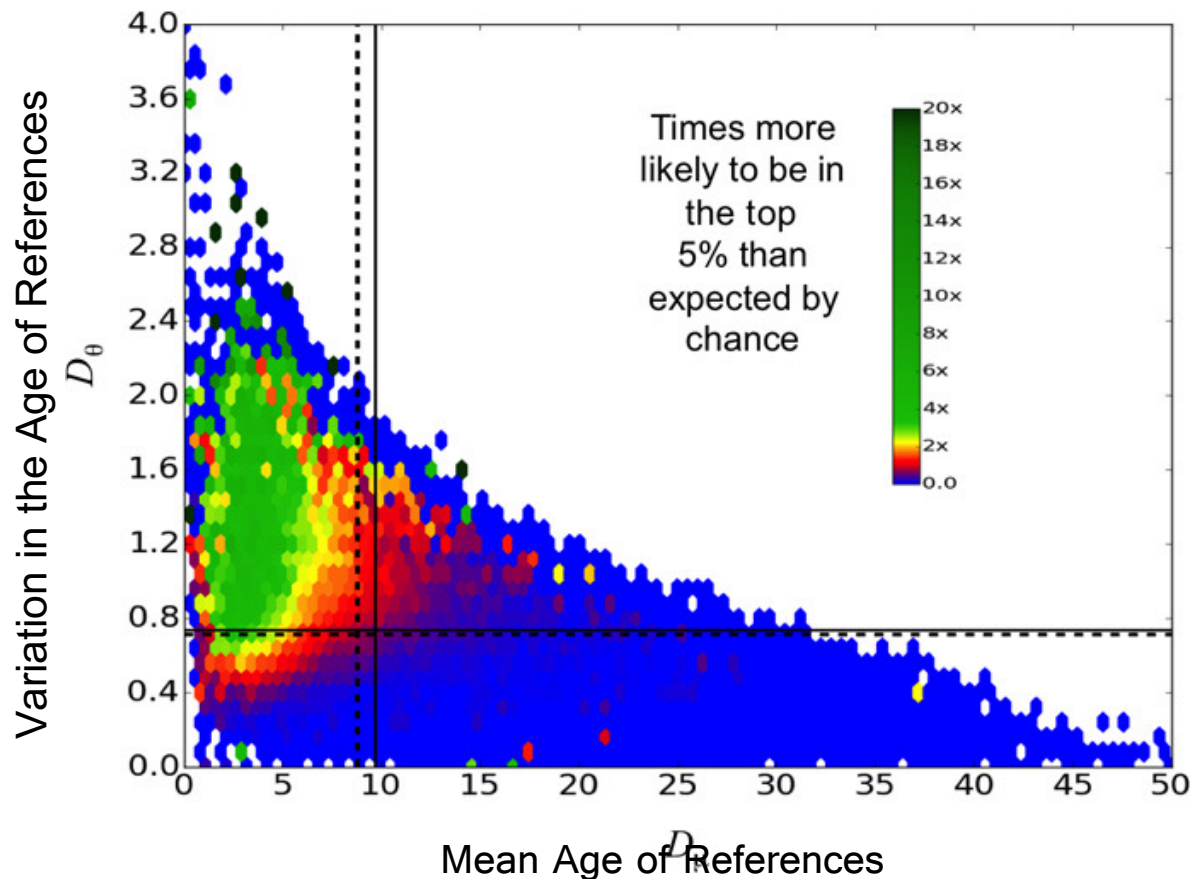


(d) Wheat

# Technology Innovations Increasingly have a Combinatorial Nature



# Combining Old and New



# Working Hypothesis

Inclusive and diverse teams in the convergence research paradigm will innovate more effectively to generate valuable new technologies and add value to society.

# ECE Should Lead and Contribute

ECE is central in several of the biggest emerging technology opportunities: AI/ML, QIS, wireless, robotics and automation, beyond Moore's Law, smart grids, ...

ECE can play a significant role in addressing societal problems: energy and climate, future of work, health and aging, resilient infrastructures, cybersecurity, ...

**ECEDHA is a key leadership group in the innovation ecosystem to make a big positive impact.**

**Comments**

**Ideas**

**Questions?**

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