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# Convergence Research Paradigm: A Powerful Approach to Enable Major Advances

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# Outline

Convergence Paradigm

Convergence for Biomedical Research

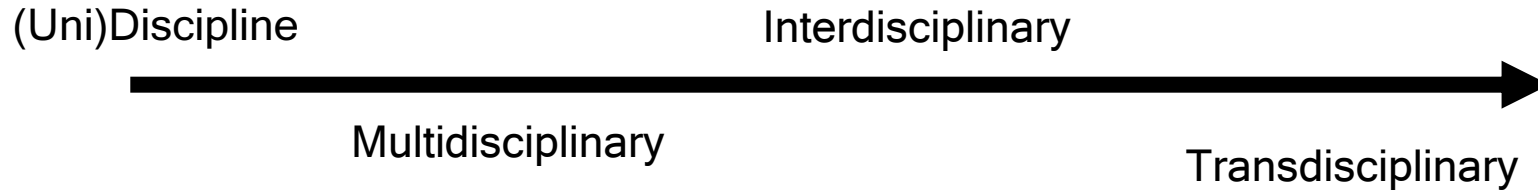
Convergence and Team Science at UCI

Inclusion and Diversity

Conclusions

# Definitions and Terminology

# 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: Recent Reports and Initiatives**



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.

# Four Key Pillars

- People
- Organization
- Culture
- Ecosystem

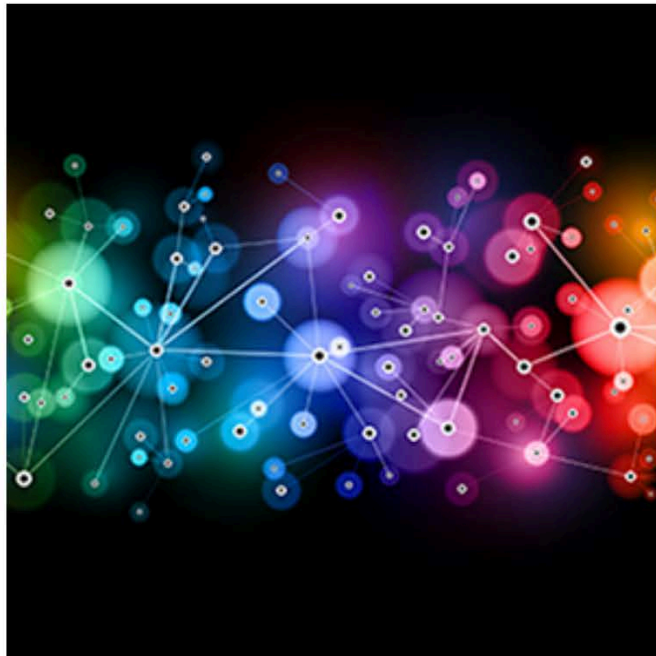
# NSF's 10 Big Ideas: Growing Convergence Research

## Growing Convergence Research

Framing challenging research questions at inception, and fostering the collaborations needed for successful inquiry.

The grand challenges of today -- protecting human health; understanding the food, energy, water nexus; exploring the universe at all scales -- will not be solved by one discipline alone. They require convergence: the merging of ideas, approaches and technologies from widely diverse fields of knowledge to stimulate innovation and discovery.

The National Science Foundation is well positioned to foster convergence: We have deep connections to all fields of S&E and have been supporting interdisciplinary research for decades. Convergence blends scientific disciplines in a coordinated, reciprocal way and fosters the robust collaborations needed for successful inquiry. Convergence builds and supports creative partnerships and the creative thinking needed to address complex problems.



# Growing Convergence Research at NSF

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 ...

# **Convergence on Biomedical Challenges**



BIOMEDICAL ENGINEERING

# *Capitalizing on convergence for health care*

Integrate physical sciences, engineering, and biomedicine

*By* **Phillip Sharp, Tyler Jacks,  
Susan Hockfield\***

great convergence, which brought together  
physical sciences and engineering and which

# Example Themes in the MIT Report

Imaging

Nanotechnology

Regenerative engineering and medicine

Big data, machine learning for health

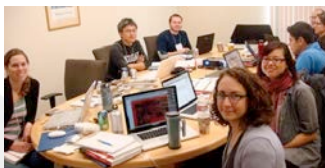
# **Convergence and Team Science at UCI**

# UCI Center for Complex Biological Systems

Biological Sciences  
Medicine  
Mathematics  
Physics  
Computer Science  
Engineering  
Statistics  
Philosophy of Science

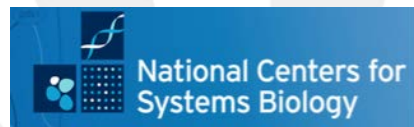
Biological  
Systems  
Research and  
Education





Mathematical,  
Computational & Systems  
Biology Training Program

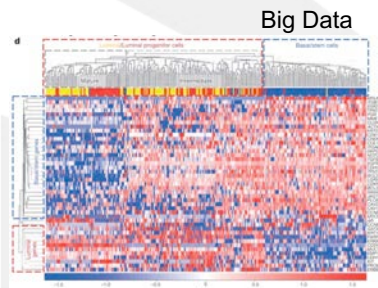
# NIH National Center for Systems Biology



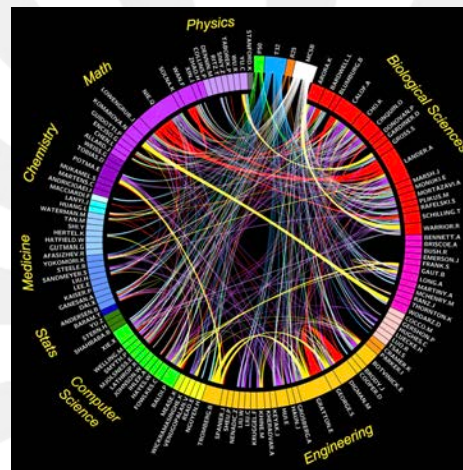
NCI Cancer Systems Biology Center



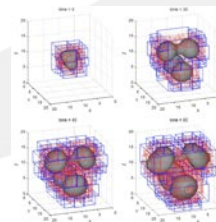
NSF/Simons Center  
for Multiscale Cell  
Fate Research



Big Data



Mathematical  
Modeling



Southern California Regional  
Conference in Systems Biology



International Outreach



COSMO



NIH Short Course in  
Systems Biology:  
Foundation for  
Interdisciplinary Careers



# CaSB@UCI

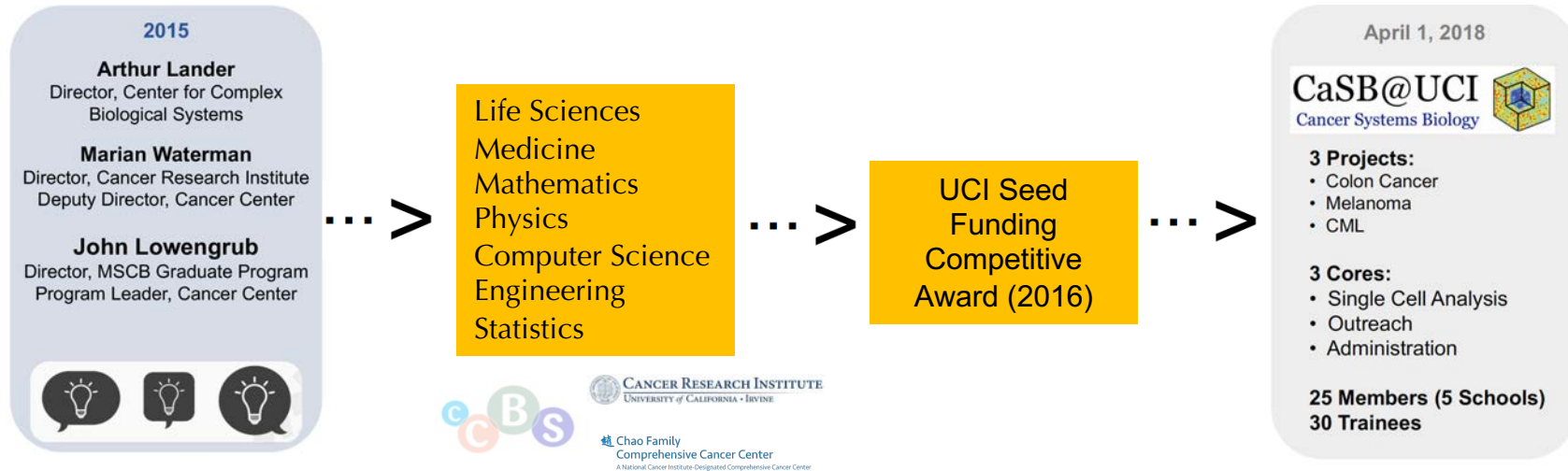
## Cancer Systems Biology at UC Irvine



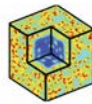
Supporting interdisciplinary approaches to cancer research

## Complexity, Cooperation and Community in Cancer

Cancer is a disease of relationships, among the cells of a tumor, between tumor cells and the tissues in which they grow, and between tumor cells of the immune system.



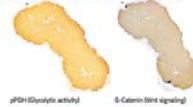




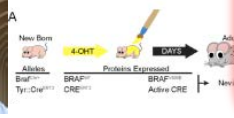
## Project I: Patterned Heterogeneity in Colon Cancer



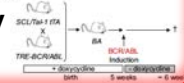
Spatial Patterns of Wnt & Glycolysis



## Project II: Understanding the Cellular Origins of Melanoma



## Project III: Modeling Malignant Myelopoiesis: Increasing Targeted Leukemia Therapy Effectiveness



## Core: Single cell sequencing



UCI U54  
Data Portal

For Cancer Single Cell Data Sharing and Exploration

S. Sandmeyer



## Core: Outreach

Seminars, Short courses, Youth Programs, Retreat, Interest groups, Workshops, Conferences,...



## Core: Administration



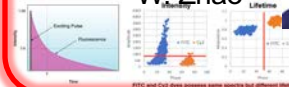
Organizational framework, Logistical Support, Pilot grant program, Oversight, Communication

## Pilot Grants: Two types

Mechanism-1: Students/postdocs  
3 awarded in 2018  
Mechanism-2: Faculty  
3 awarded in 2018 (+cost share)

## Administrative supplement: Validating sc transcriptomics

E. Gratton  
W. Zhao



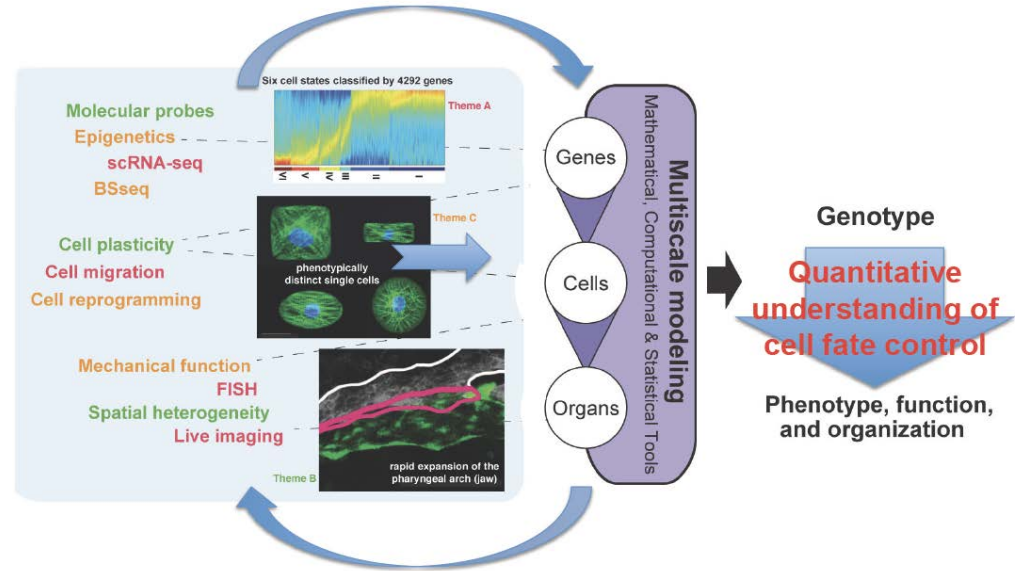


# NSF-Simons Center for Multiscale Cell Fate Research UC Irvine



- One of the four national centers on mathematics of complex biological systems jointly funded by NSF and The Simons Foundation (\$10M)
- 18 core center faculty members, 13 center graduate fellows, and 6 postdoctoral center fellows from five schools of UCI
- Director and PI: Qing Nie (Mathematics and Developmental & Cell Biology); Associate directors: Arthur Lander (Developmental & Cell Biology) and John Lowengrub (Mathematics)

## Research approaches and goals



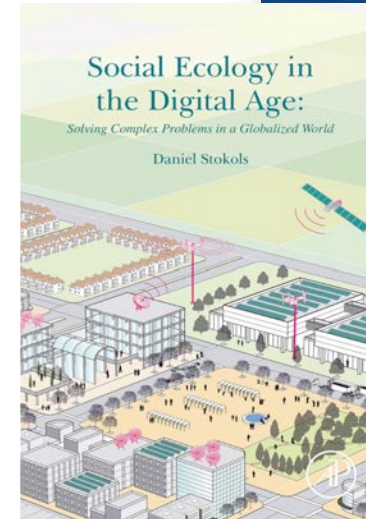
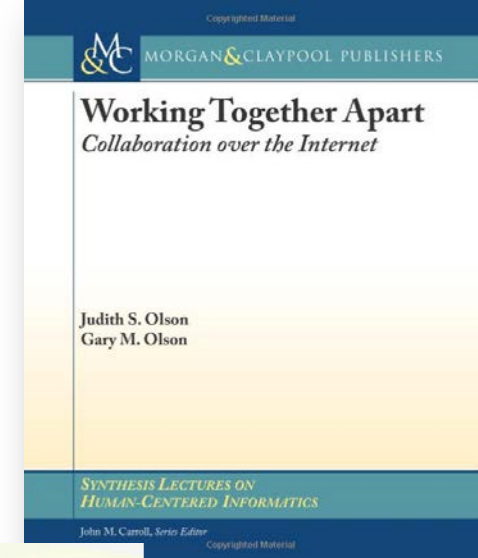
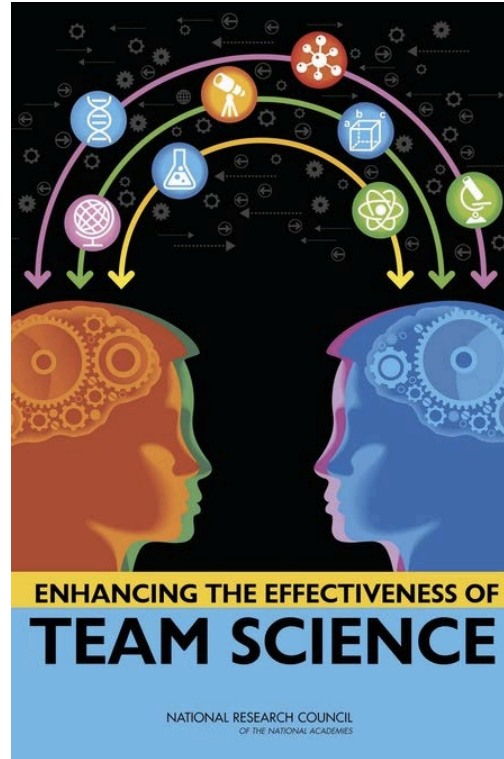
New mathematical, computational, and statistical tools  
for cell fate, and beyond



# Convergence and Team Research

## Collaboration & Team Science:

*A Field Guide*



# Advancing Team Science at UCI: Team Science Accelerator Lab (TSAL)

Judith Olson



Gary Olson



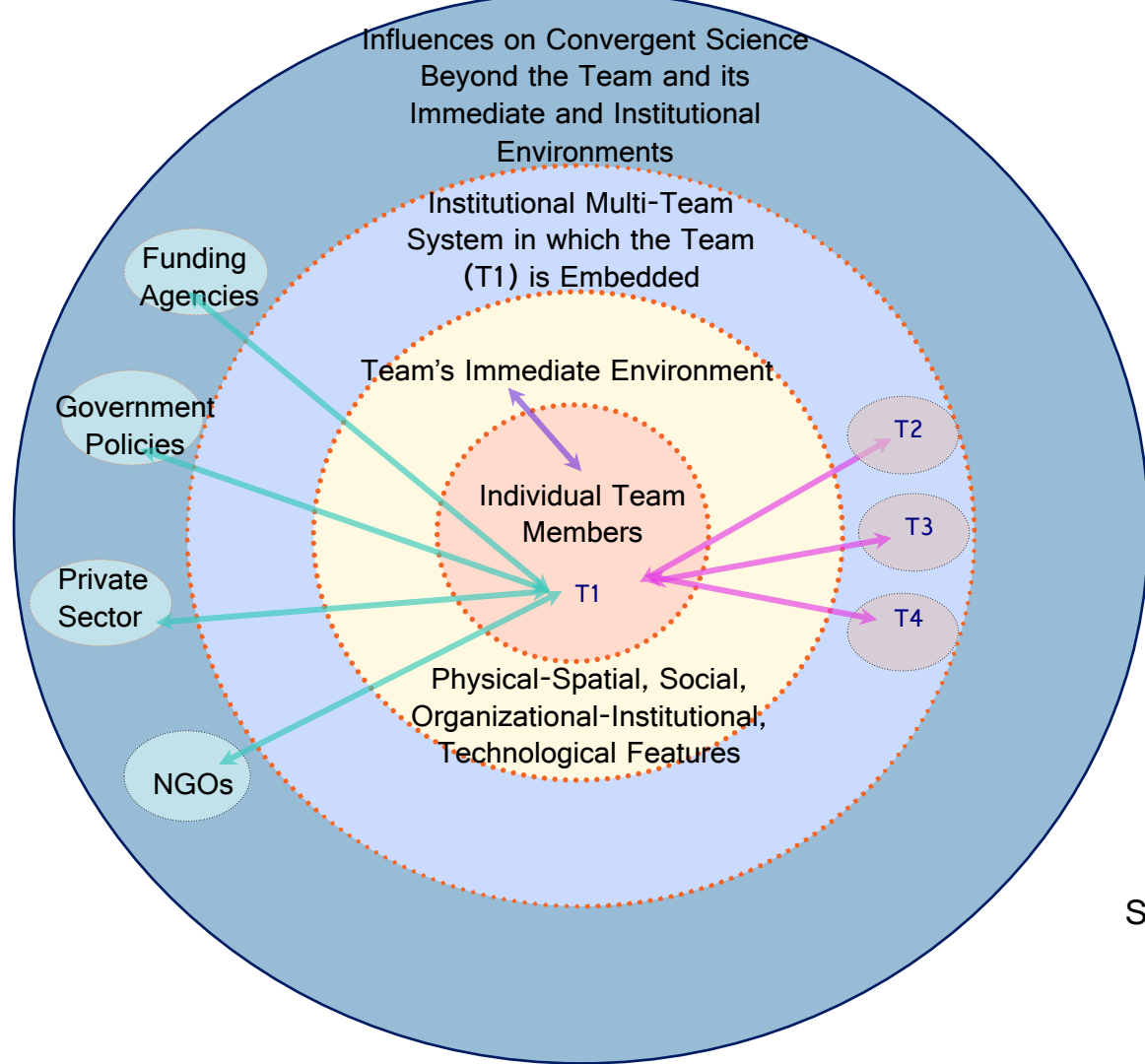
Maritza Salazar



Dan Stokols



Convener: Pramod P. Khargonekar



Stokols, 2018

# 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.)*

# Improving Team Research Effectiveness

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

# Training Resources for Team Science



<https://www.teamsciencetoolkit.cancer.gov>



**NUCATS**  
CLINICAL AND TRANSLATIONAL SCIENCES INSTITUTE

Supported in part by CTSA grant  
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N01-LM-6-2012 from the Office of  
Behavioral & Social Sciences  
Research (PI: Bonnie Spring)



<http://www.teamscience.net>

## Collaboration & Team Science:

*A Field Guide*



<https://ccrod.cancer.gov/confluence/display/NIHOMBUD/Home>

<http://www.scienceofteamscience.org/scits-a-team-science-resources>

# Recognizing Individual Contributions to Team Science in Promotion and Tenure Reviews



**Team Science Collaborative Index**  
(4/17 draft developed by Drs. Martina Salazar and Dan Stokols  
in collaboration with UCI's Institute for Clinical and Translational Sciences)

UCI is dedicated to supporting inclusive excellence and seeks to recognize and reward faculty for their contribution to collaborative teamwork. The *Collaborative Index* (CI) provided below is intended to help tenure-track faculty assess the ways in which they have contributed to the teams with whom they conduct academic research. Although completion of the CI is not mandatory, it can be used as a tool to help you articulate your contributions to team science as part of the merit and promotions review process and as you in prepare your research statement.

For any of contributions listed below that you've made in your research, briefly describe how you contributed to collaborative effectiveness in a particular research, teaching/mentorship, and/or service activity

Using the numbering system in your MyData profile, list publications, grant proposals, or other evidence of your contributions to collaborative scholarship, teaching/mentorship, and/or service

	Briefly describe your contribution	Corroborating evidence
1.	I've presented novel theoretical ideas and/or conceptual frameworks to the research team	
2.	I've developed integrative assessments of cross-disciplinary research findings that helped to advance scientific understanding of a particular problem domain	
3.	I've facilitated discovery and presentation of important new empirical findings derived through interdisciplinary research	
4.	I've contributed to the translations of team-based research into innovative clinical practices and/or medical devices	
5.	I've provided significant interpersonal support in helping to build the team (e.g. bringing together prospective team members and facilitating effective collaboration among team members)	
6.	I've contributed significantly to the development of the team's grant proposal	



## Interdisciplinary Science and Engineering Building

**204,750 SQ ft.**  
includes laboratory  
support space,  
conference and  
collaboration spaces



# 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 to success

# Concluding Comments

Convergence is a powerful paradigm to address complex problems

Great potential for discovery and translation

Major attractor for diverse talents but

There are critical barriers to progress along this theme

Institutions have much work to do realize this potential

**Comments**

**Ideas**

**Questions?**

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<http://faculty.sites.uci.edu/khargonekar/>