Session III – NSF Centers that Catalyzed Extraordinary Engineering Impacts on Society

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National Science Foundation

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- **NSF Engineering Research Centers**

https://www.nsf.gov/pubs/2022/nsf22580/nsf22580.htm

https://beta.nsf.gov/funding/opportunities/gen-4-engineering-research-centers-erc

https://erc-assoc.org/

https://erc-history.erc-assoc.org/ (ERC History Book)

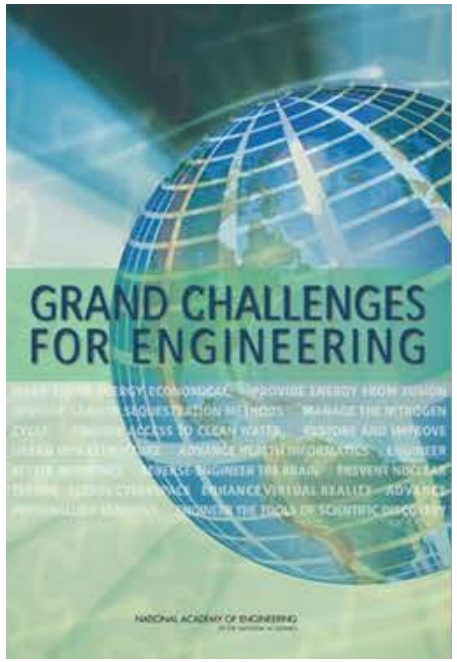
https://www.nsf.gov/pubs/2022/nsf22104/nsf22104.pdf (FY 2020 Engineering Research Centers Program Report)

……..

The State of the Engineering Discipline

- Emerging and convergent research to address grand challenges
- Globalization
- Changes in education and workforce development model

Emerging & Convergent Research



https://www.un.org/sustainabledevelopment/news/communications-material/

- Many Grand Challenges – NAE GC, UN SDG, NSF Big Ideas, etc.
- Call for engineers to address **big societal problems** with contemporary issues and achieve **high impact** to **humanity**
- Need to build a strong ***core*** in ***engineering*** research, and at the same time ***cross the boundaries*** and ***absorb new emerging areas***

Emerging & Convergent Research

- Foster ***Convergence*** with ***depth*** and ***breadth***
- Build a ***diverse workforce*** with ***inclusion*** → tackle ***grand challenges*** with high ***impact on society!***

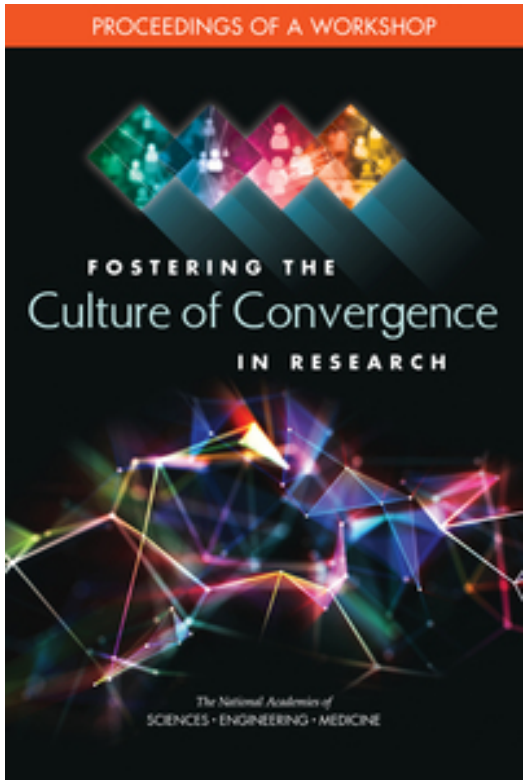
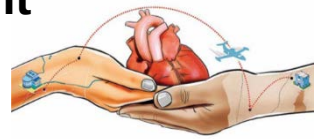
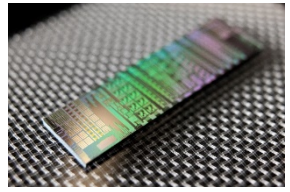


Image: *National Academies Press, Copyright 2017, National Academy of Sciences*

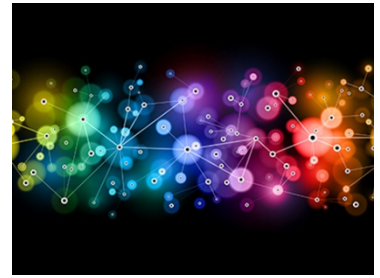
NSF Gen-4 Engineering Research Center (ERC): Convergent Research and Innovation through Inclusive Partnerships and Workforce Development





NSF Convergence Accelerator 2022

- Enhancing Opportunities for Persons with Disabilities
- Sustainable Materials for Global Challenges
- Food & Nutrition Security



Globalization

- **More & more international competitions as well as international collaborations**
  - ➢ US is facing serious international competitions in S&E research investments and productivity (PhD degree, paper #, expenditure, etc.)
  - ➢ International collaboration increased; e.g., Cross-nation programs, Co-authored papers among multi-national authors

Globalization

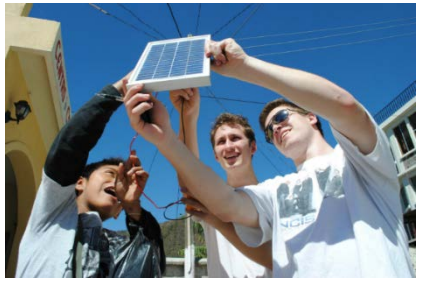
US Looking Beyond First-World Problems

- Many grand challenges are global challenges
- Create engineering solutions to address global issues

Engineering for the Global Good and Greater Impact

NAE Grand Challenges Scholars Program

Engineers Without Borders USA



BLUElab

Better Living Using Engineering

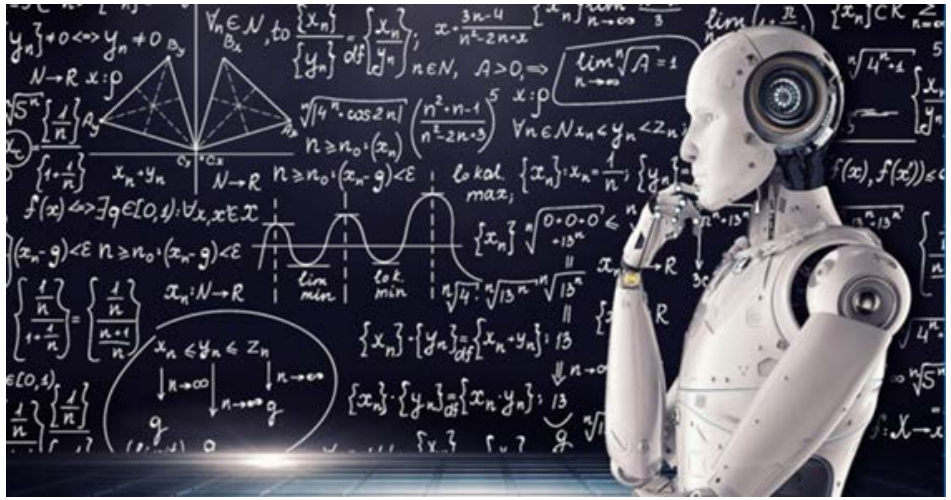
Global Health Design Initiative

Workforce Development Model

- To compete in **world market**, **engineering expertise** will be required at a **higher** level… **other emerging** and **professional skills** (e.g., communication, leadership, team formation & dynamics, international experience, etc.) to work effectively in a **diverse and convergent** environment are becoming more and more **important**

Workforce Development Model

- Utilizing **new technologies**, such as AI, and cyber and virtual learning, to enhance **education** and **workforce development**, including **K-12**, and **personalized** and **life-long learning** beyond university
- **COVID-19** forced changes that may create opportunities for the **post-pandemic** era



An Exciting Time for Engineering!

Carpe Diem - Seize the Moment...

A time to tackle the **grand challenges** and **impact society** through transformative **convergent research** and **educating** a **generation** of **diverse and inclusive workforce**!

An Exciting Time for Engineering!

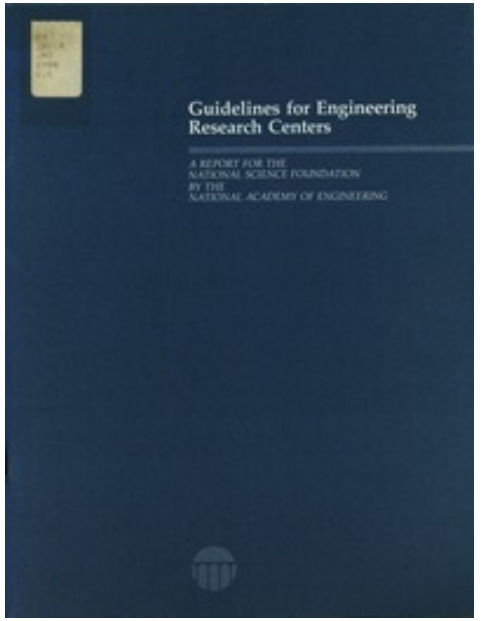
Carpe Diem - Seize the Moment…

Since its initiation, the **NSF ERC Program** has always been **evolving** to take on the **challenges** and harness the **opportunities** so to **lead** the national and global **trends** to **impact technology, society** and **humanity!**

Engineering Research Center (ERC) Program

Launched in 1985 - based largely on guidelines proposed by the National Academy of Engineering

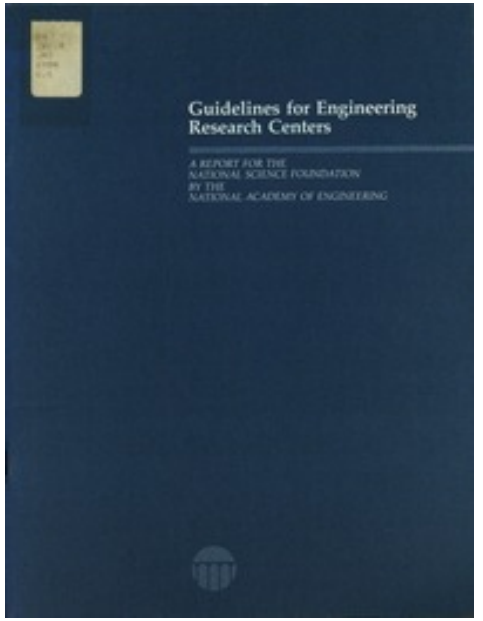
The goal is to improve engineering research so that U.S. engineers will be better prepared to contribute to engineering practice and to assist U.S. industry in becoming more competitive in world markets



Engineering Research Center (ERC) Program

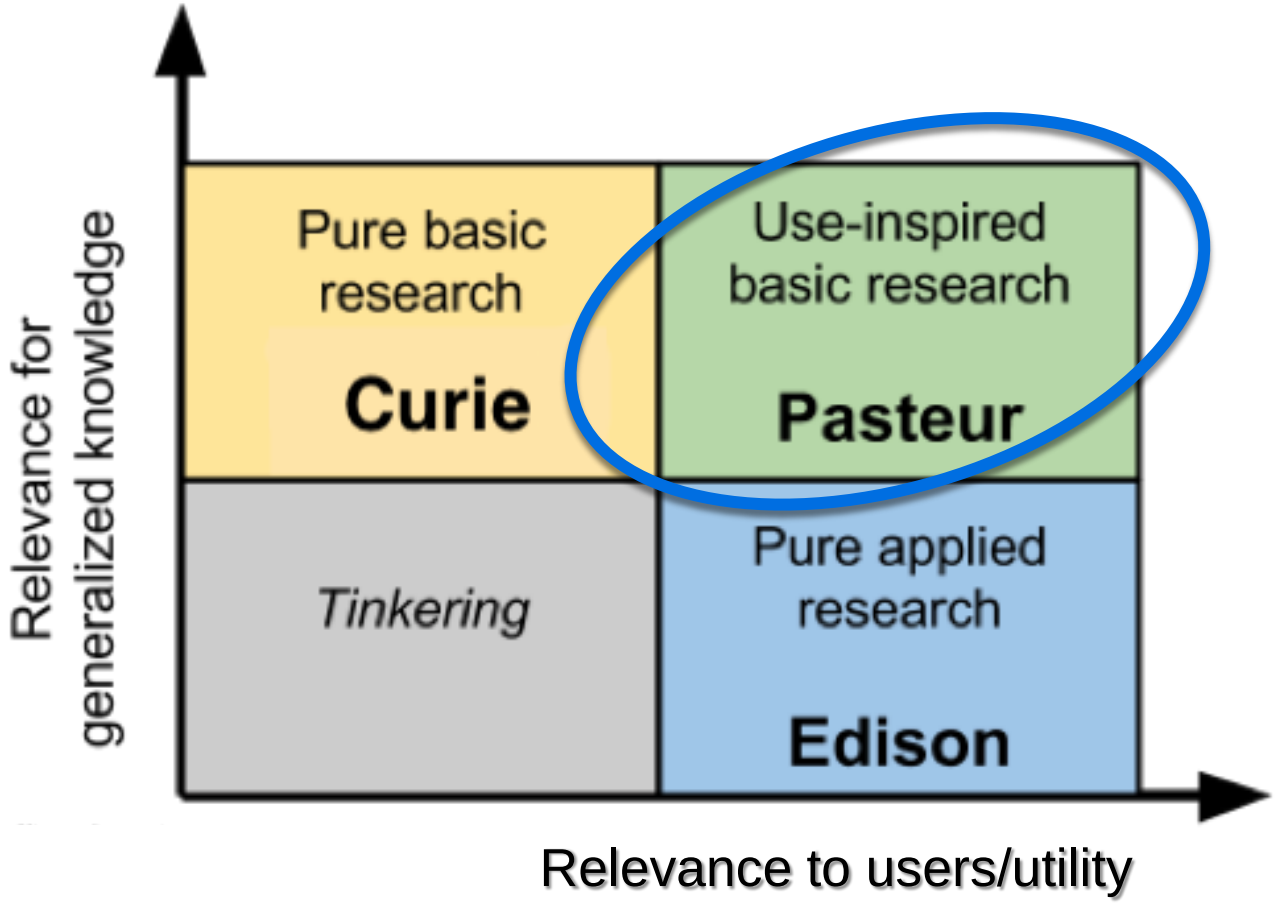
Launched in 1985 - based largely on guidelines proposed by the National Academy of Engineering

- Cross-disciplinary transformative basic research
- Translate research discovery to innovative products
- Strengthen the competitiveness of the U.S.
- Firmly link research and education and prepare next generation of technological leaders



Distinguishing Features of an ERC

- Engineering ***systems*** focus
- ***Large-scale*** and ***long-term*** program spans the gamut from transformative **basic research** to **technology**
- A ***10-year*** strategic plan with max $4M per year from NSF in the past, now max ***$6M/year*** (new generation); and sustain way beyond



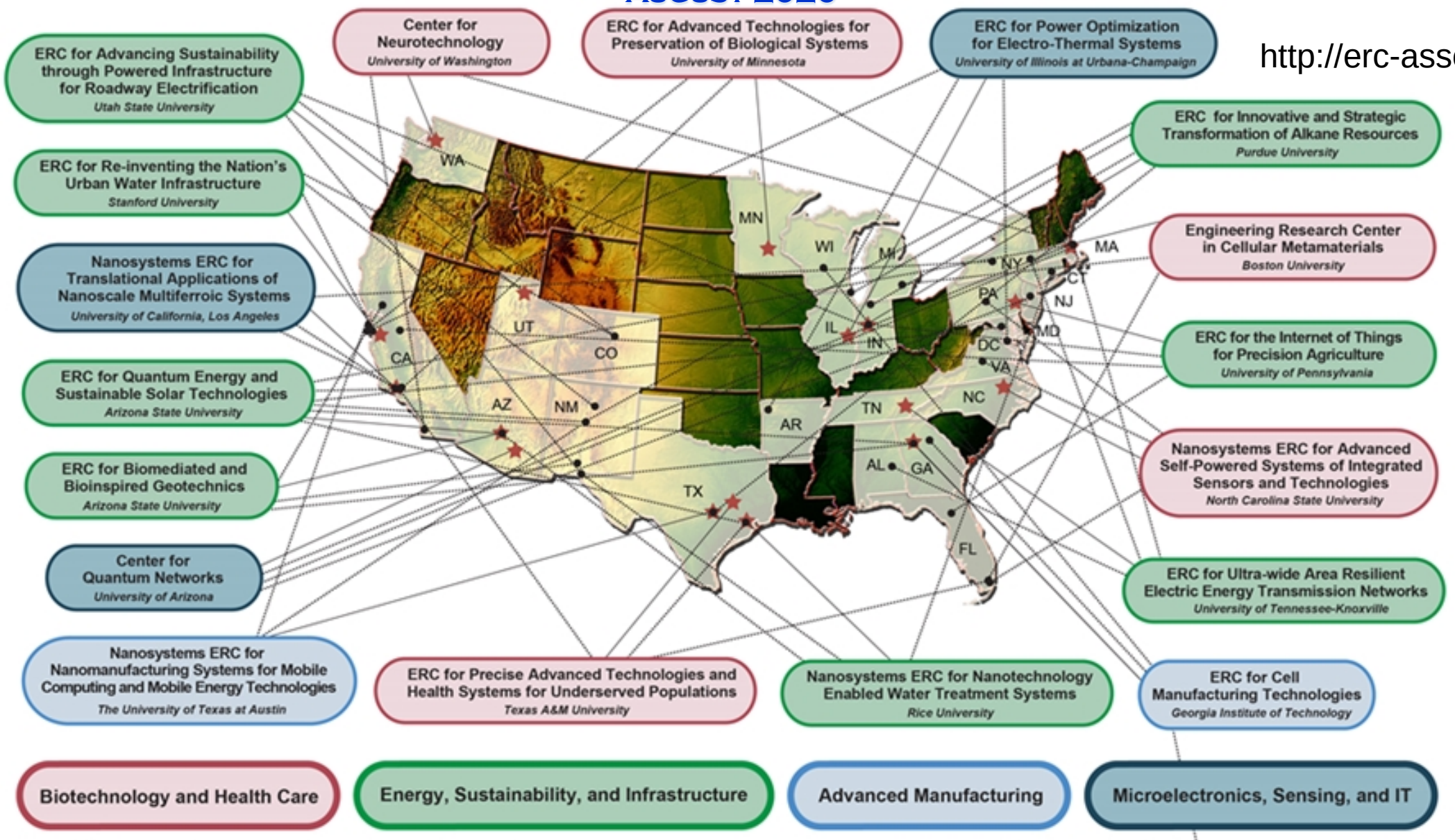
4 Generations of ERCs

- Generation 1 (1985-1990) aimed for interdisciplinary, transformational research at a **single host university** with **industry engagement**.
- Generation 2 (1994-2006) required the lead university to engage with **multiple partner universities**, to develop **strategic plans** showing the **pathway** from **fundamentals** through **enabling technology** to **systems** integration, to **increase diversity** at all levels and include a **minority-serving university**, to **expand the education mission** and establish **outreach** programs to pre-college (K-12) educational institutions.
- Generation 3 (2008-2017) sought to transform engineered systems and **develop a globally competitive** and **diverse engineering workforce**, to provide cross-cultural, global research and educational experience through **partnerships with foreign universities** and other means.
- Generation 4 (2019 -) First cohort started in 2020.

NSF ERC Institutions

August 2020

http://erc-assoc.org/



NSF ERC Program

NSF has supported 79 ERCs

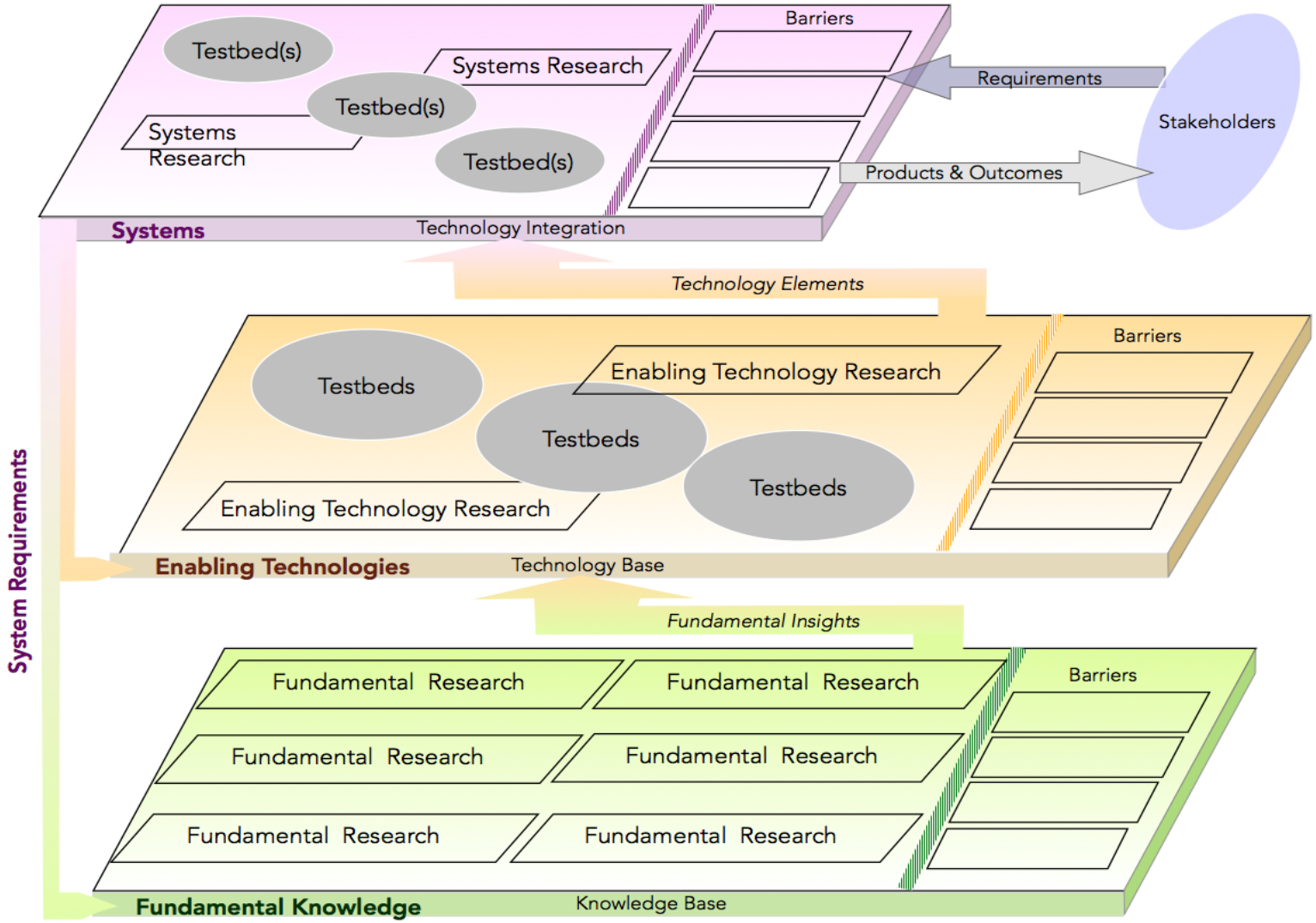
- Over 25,000 peer reviewed journal publications and books
- More than 800 patents, 1300 licenses, and 2500 invention disclosures,
- More than 240 spinoff companies,
- More than 14,400 total bachelors, masters and doctoral degrees to ERC students, and
- Numerous research outcomes enabling new technologies

NSF ERC 3-Plane Diagram

Systems Plane

Enabling Technologies Plane

Fundamental Knowledge Plane

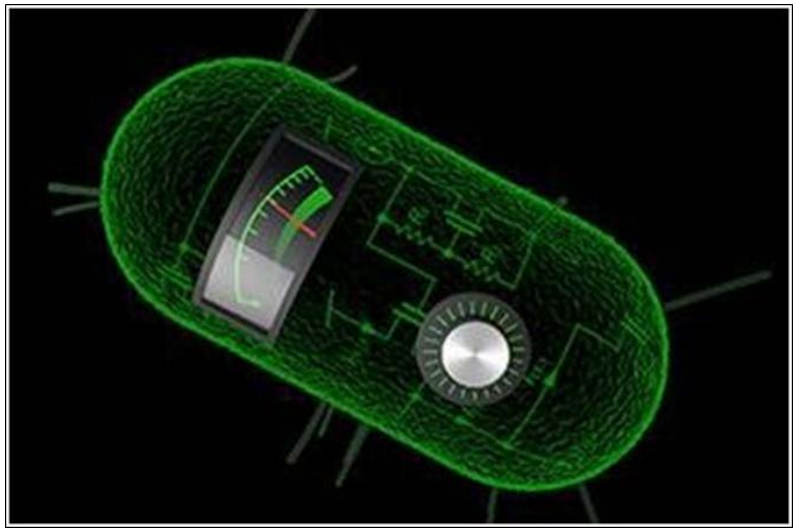


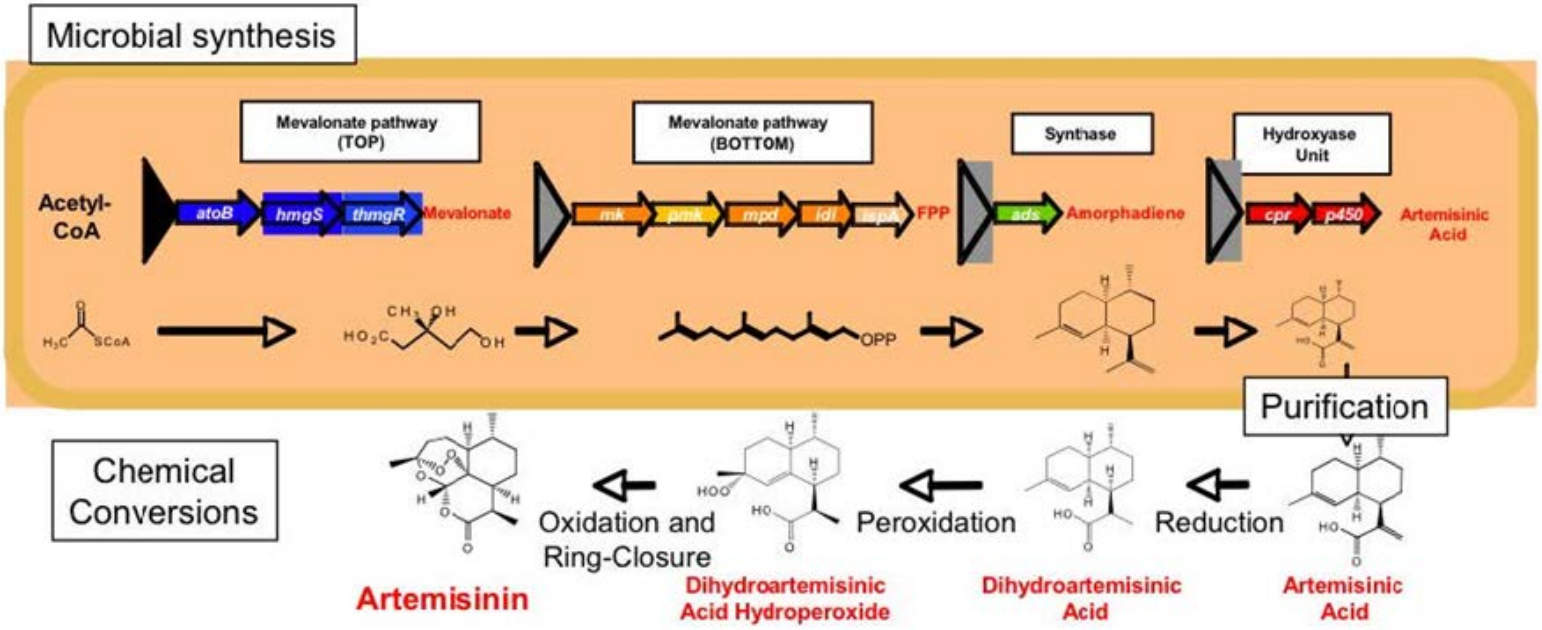
https://erc-assoc.org/content/three-plane-diagram

ERC Example – "SynBERC" (2006-16)

Synthetic **B**iology **ERC** (SynBERC)

- A microbial process for inexpensively producing the anti-malarial drug, artemisinin, passed through a spinoff to a major company (Sanofi-Aventis) for scale-up production and to the Institute for One World Health for delivery to malaria-afflicted areas in Africa → **Saving lives!**





Credit: Amyris Biotechnologies, Inc
http://erc-assoc.org/content/amyris-biotechnologies

ERC Example – "CASA" (2003-13)

Collaborative **A**daptive **S**ensing of the **A**tmosphere

- **Revolutionize** our ability to predict **hazardous weather** by creating ***Distributed Collaborative Adaptive Sensing*** Doppler radar networks that sample the lower atmosphere where and when end-user needs. Up-to-the-second information then be transmitted to make critical decisions.
- Used by NBC Universal in on-air broadcasts and the National Weather Service to support communication of weather hazards and decision making to **save lives and property**.

May 3, 2018, powerful storms swept through North Central Texas, endangering lives and property.

http://www.casa.umass.edu/index.php

A New Vision for Center-Based Engineering Research

Committee on a Vision for the Future of Center-Based Multidisciplinary Engineering Research

National Materials and Manufacturing Board
Division on Engineering and Physical Sciences
National Academy of Engineering

http://www.nap.edu/24767

May 2017

NASEM Report Overarching Statement

*"…… the committee believes it is important to **build upon the existing strengths** of the ERCs by framing them **to address the biggest challenges society faces both today and in the decades to come**……"*

-NASEM Report Preface

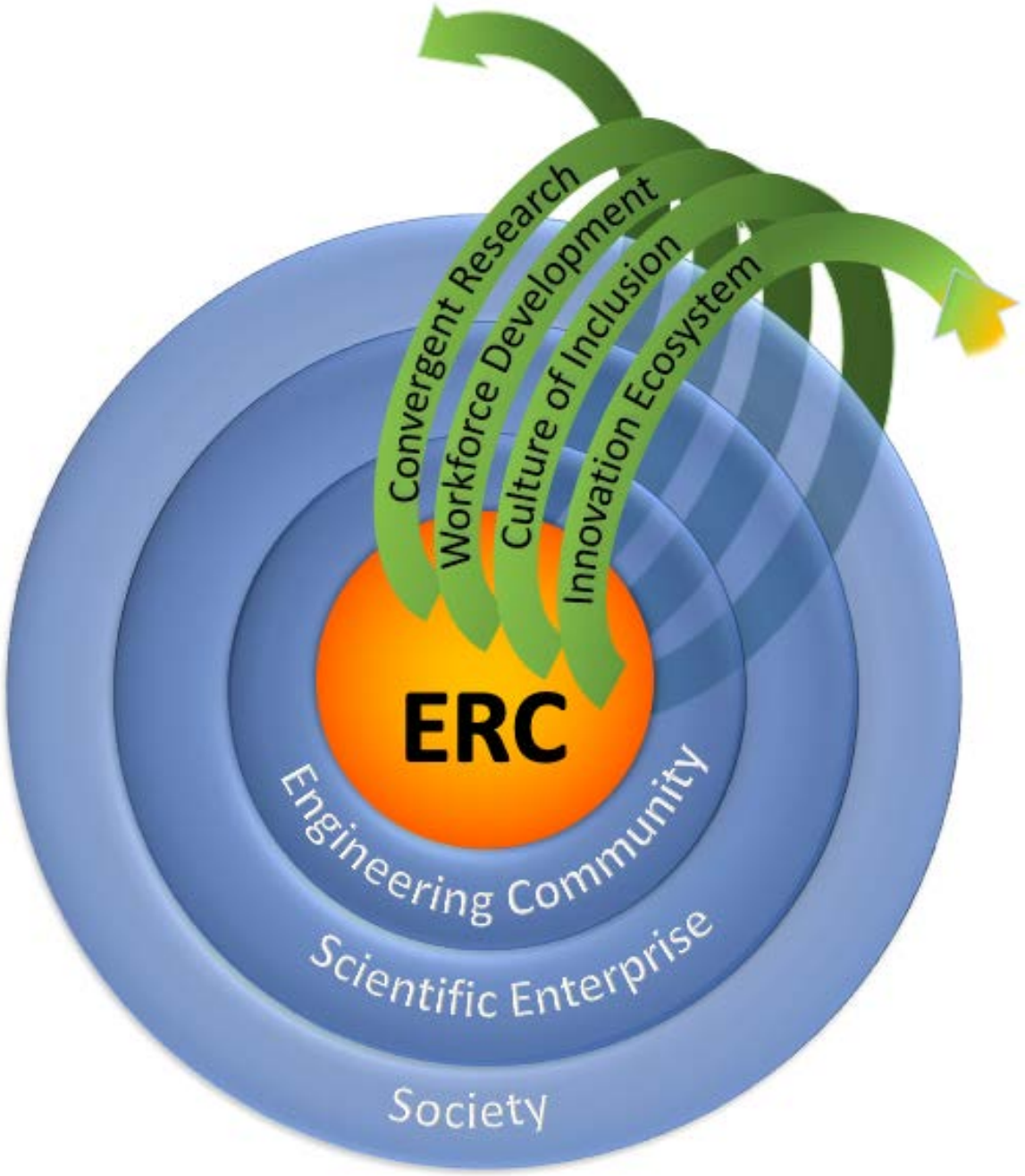
Gen-4 Engineering Research Centers (ERCs)

Per NASEM and NSF Working Group Recommendations

Convergent Research and **Innovation** through **Inclusive Partnerships** and **Workforce Development**

- Emphasizes **societal impact**, **convergence**, **stakeholder community**, and **team formation**
- Increase **award size** to max **$6M/year**
- Implement a **pilot planning grant opportunity** to enhance **convergent team formation**
- Demonstrable **integration** of **foundational components**

New Gen-4 ERC Program

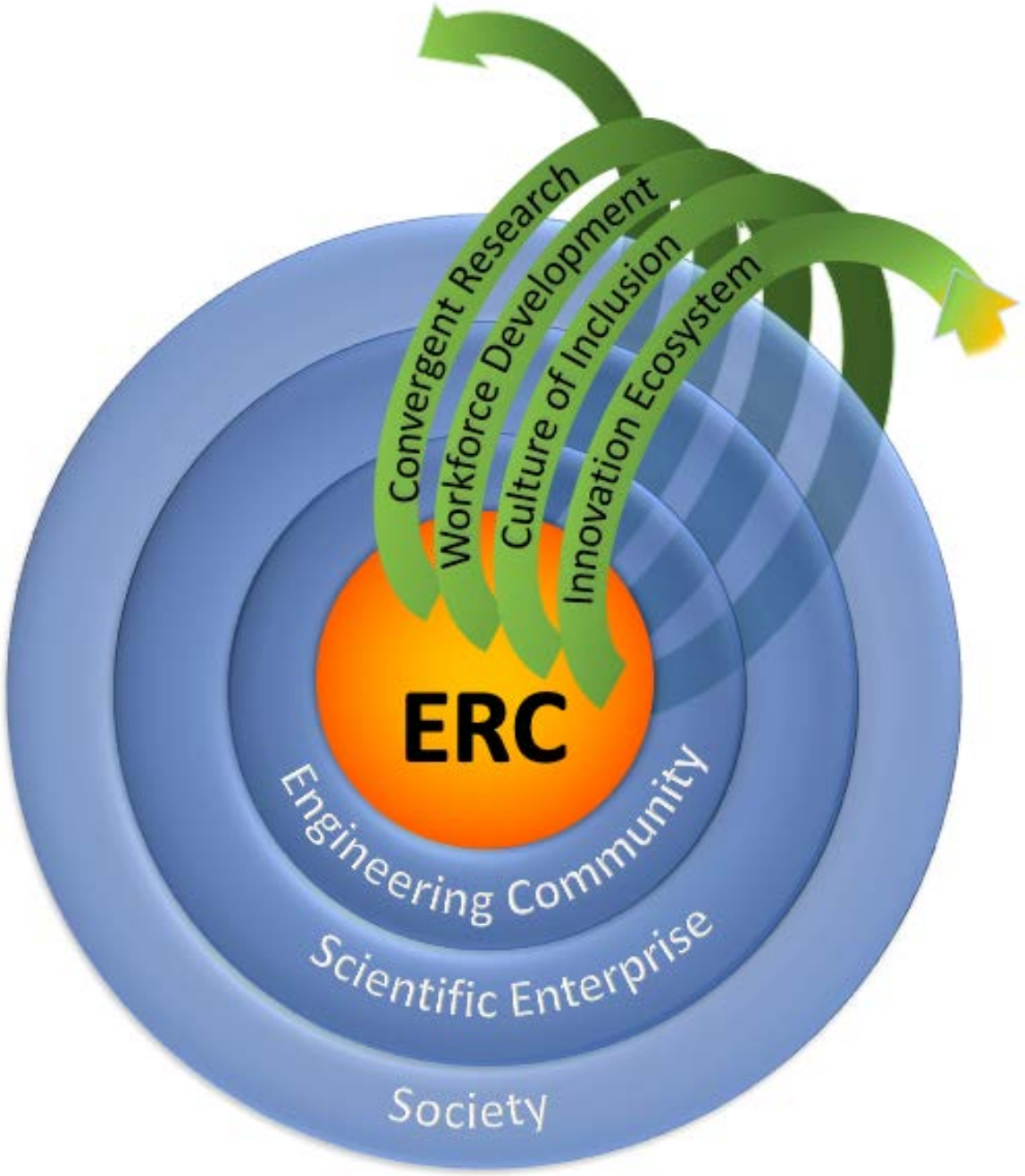


Four interconnected **foundational components**

- **Convergent Research**
- **Workforce Development**
- **Diversity & Culture of Inclusion**
- **Innovation Ecosystem**

https://www.nsf.gov/pubs/2022/nsf22580/nsf22580.htm

New Gen-4 ERC Program

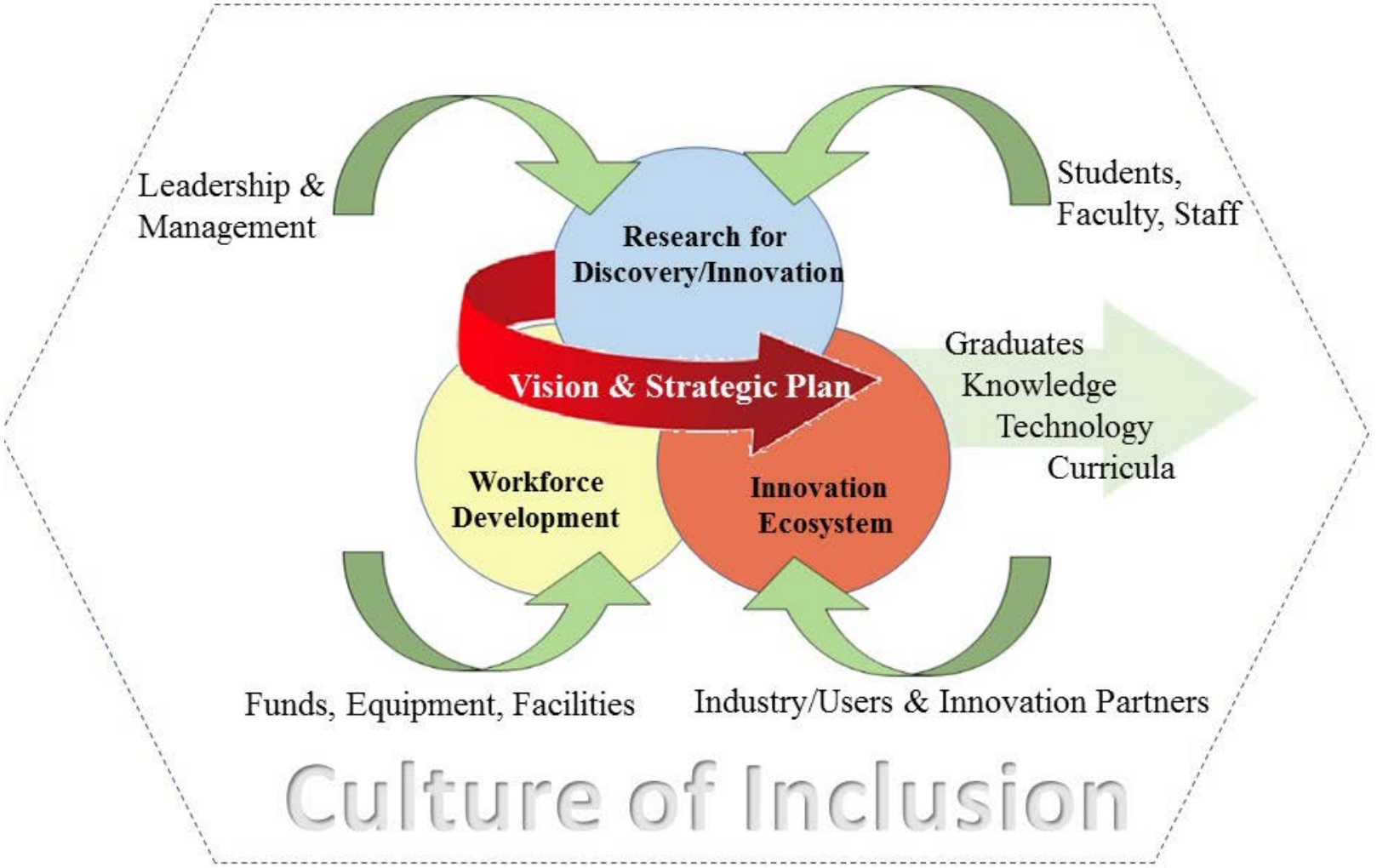


Three layers of **impact**

- **Engineering Community**
- **Scientific Enterprise**
- **Society**

https://www.nsf.gov/pubs/2022/nsf22580/nsf22580.htm

NSF Engineering Research Center: A Complex, Interdependent System



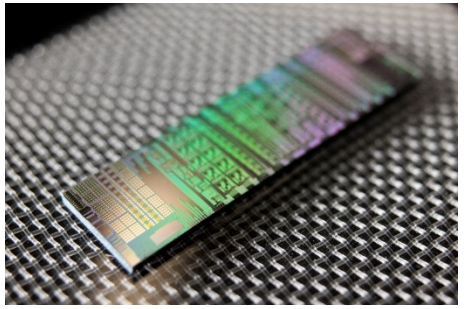
https://www.nsf.gov/od/oia/programs/epscor/presentations/Outreach/Centers/ERC.pdf

FY20 1ST Cohort Gen-4 NSF ERCs

- **Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE)**
- **Advanced Technologies for Preservation of Biological Systems (ATP-Bio)**
- **Center for Quantum Networks (CQN)**
- **Internet of Things for Precision Agriculture (IoT4Ag)**

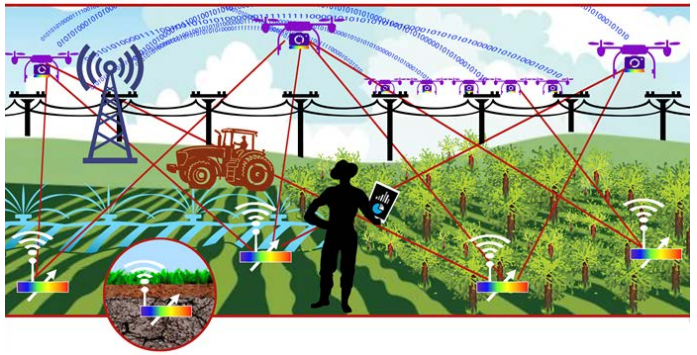
https://usu.app.box.com/s/refvtmwt3r2gazulu5abppjnex7y0dul/file/698925072223
Credit: ASPIRE, Matt Jensen

https://www.atp-bio.org/



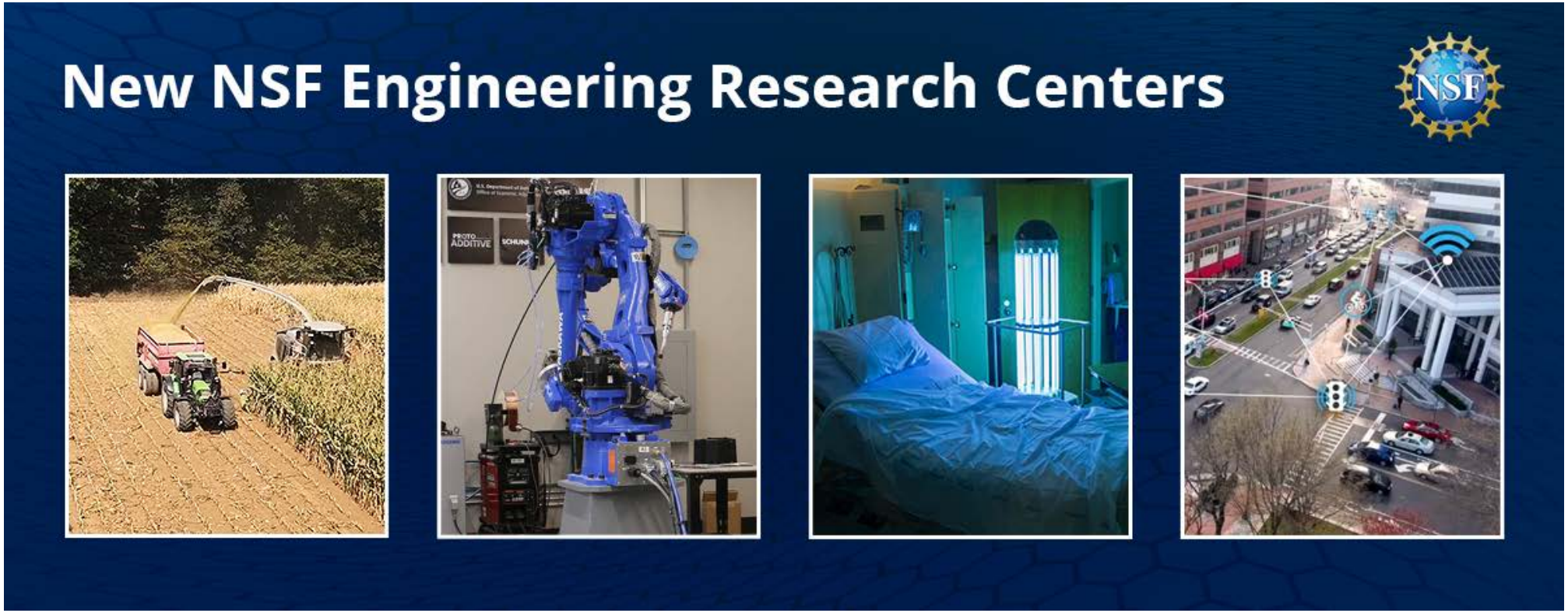
https://arizona.app.box.com/v/Center-Quantum-Networks-EPK/file/696842420813
Credit: CQN, Mark Koenig

https://iot4ag.us/iot4ag/special-report-the-internet-of-things-for-precision-agriculture-iot4ag/



FY22 2ND COHORT GEN-4 NSF ERCs

NSF announces 4 new Engineering Research Centers focused on agriculture, health, manufacturing and smart cities (August 10, 2022)



https://beta.nsf.gov/news/nsf-announces-4-new-engineering-research-centers-focused-agriculture-health-manufacturing-and
New NSF Engineering Research Centers will lead to more sustainable, prosperous, healthy, and livable communities.
Credit: U.S. National Science Foundation

Teams of Eminent Scholars as well as Passionate Movers and Shakers who Care About Making a Difference – in Research, Education and Societal Impact!

http://dynamicpickaxe.com/i-want-you-uncle-sam-clipart.html#gal_post_94710_i-want-you-uncle-sam-clipart-1.jpg

An Exciting Time for Engineering!

Carpe Diem - Seize the Moment…

Engineer the 21st Century for Humanity!

Thank You!!