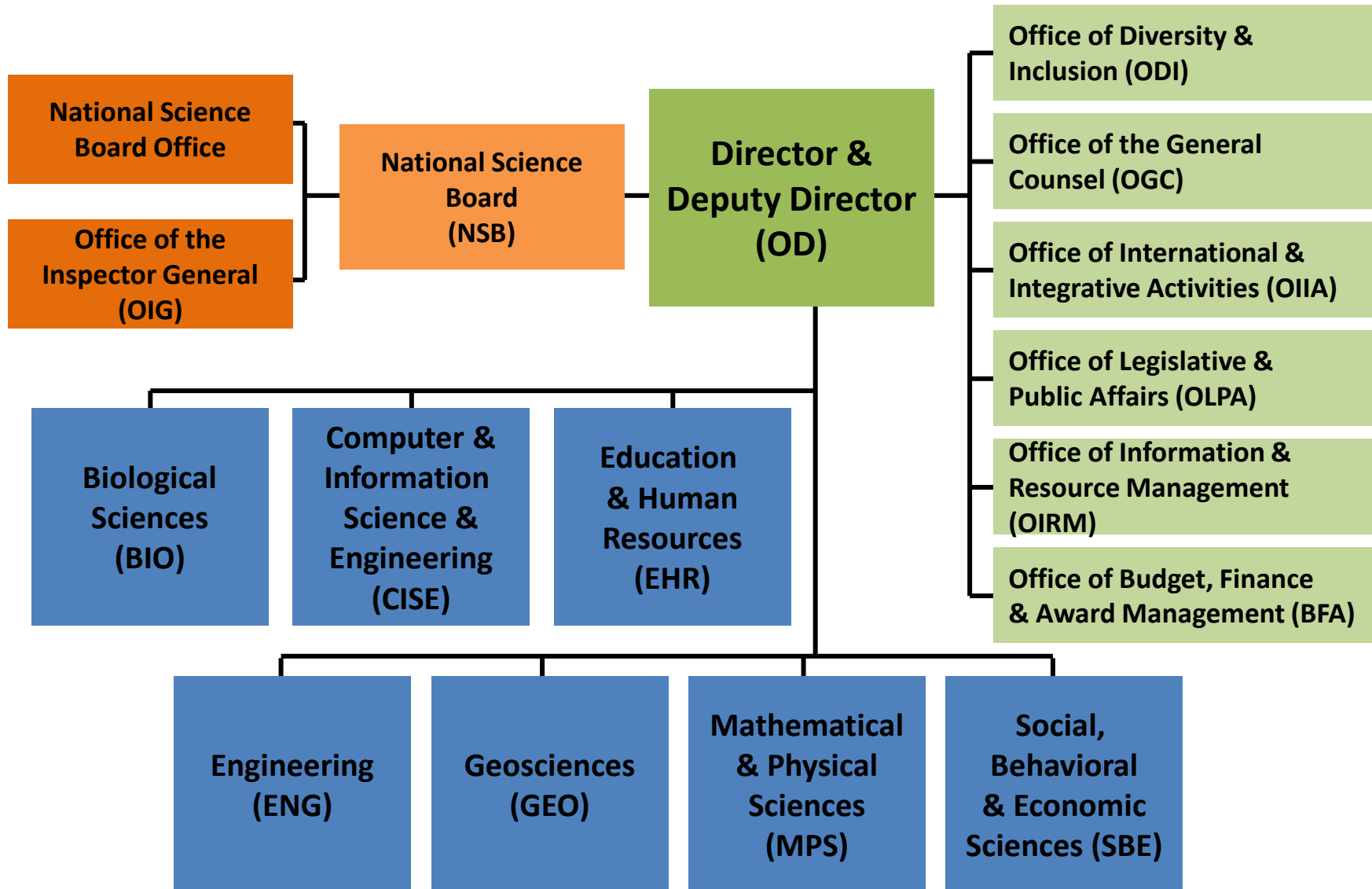


# Emerging Frontiers in Research and Innovation (EFRI)

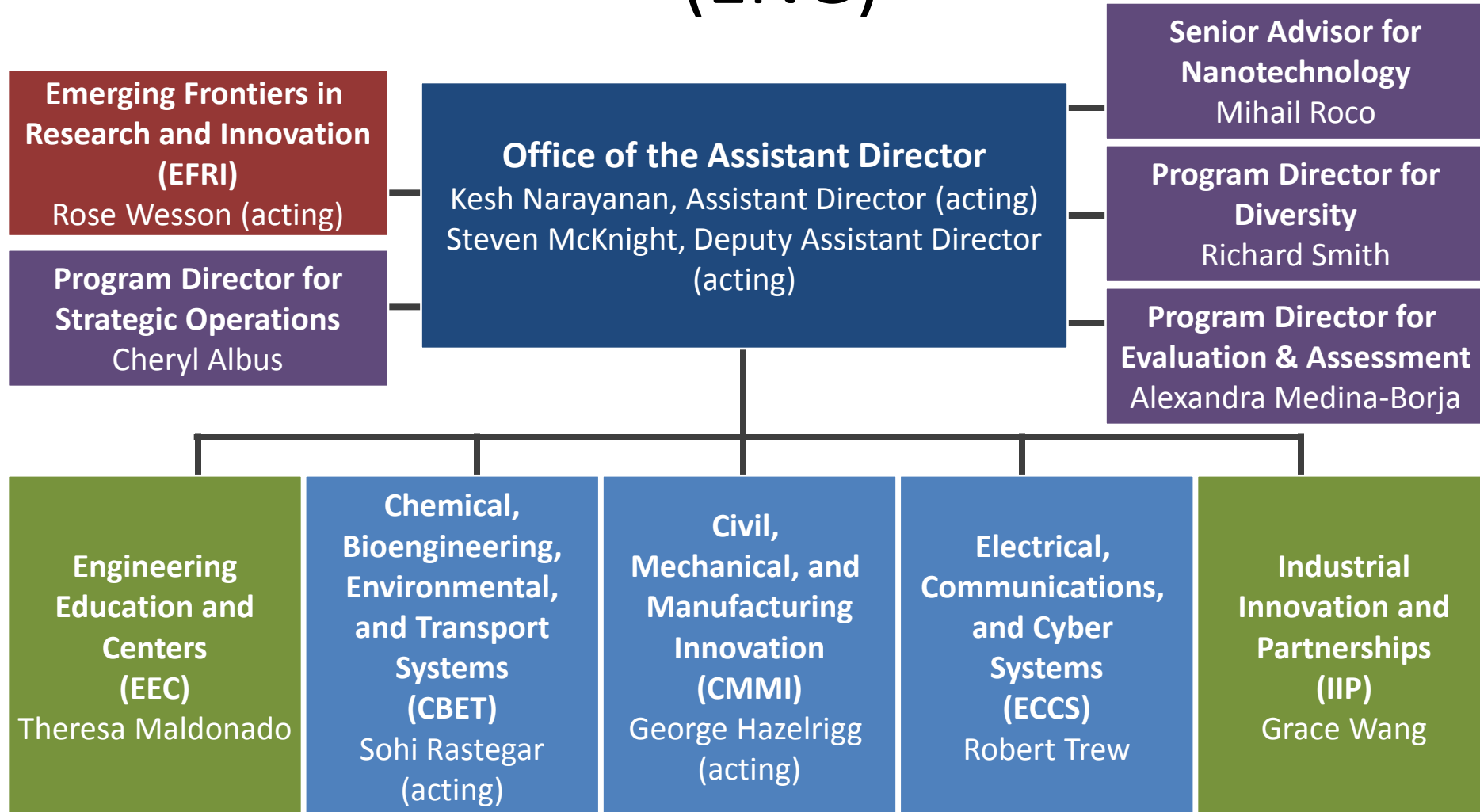
Rosemarie D. Wesson

Acting Director

# NSF Organizational Structure



# NSF Directorate for Engineering (ENG)



# MANDATE AND VISION OF EFRI

**MANDATE** - EFRI will serve a critical role in helping the Directorate for Engineering (ENG) focus on important emerging areas in a timely manner. EFRI will annually recommend, prioritize, fund, and monitor initiatives at the emerging frontier areas of engineering research and education.

**VISION** – All NSF ENG Programs support research at the frontiers of research and innovation.

EFRI Office provides opportunities in interdisciplinary areas at the *emerging* frontiers of research and innovation that (a) are transformative, (b) address national needs/grand challenges, and (c) will make ENG unrivaled in its global leadership.

# EFRI- In One Slide

- **MANDATE** - Serve a critical role in helping the Directorate for Engineering focus on important emerging areas in a timely manner.
  - **COMMUNITY DRIVEN** - Engages the research community (through DCL) and ENG/NSF PDs to identify and fund a portfolio of projects in strategic emerging interdisciplinary areas that may not be supported with current NSF programs and in which ENG researchers play the leading role.
  - **PTR AND IDR** - Uses PTR (Potentially Transformative / High risk, High reward) and IDR (interdisciplinary) as criteria for project selection
  - **MIDSCALE BUDGET** - It is the main Midscale funding mechanism in ENG (\$2M / 4-year projects)
- **EFRI TOPICS:**

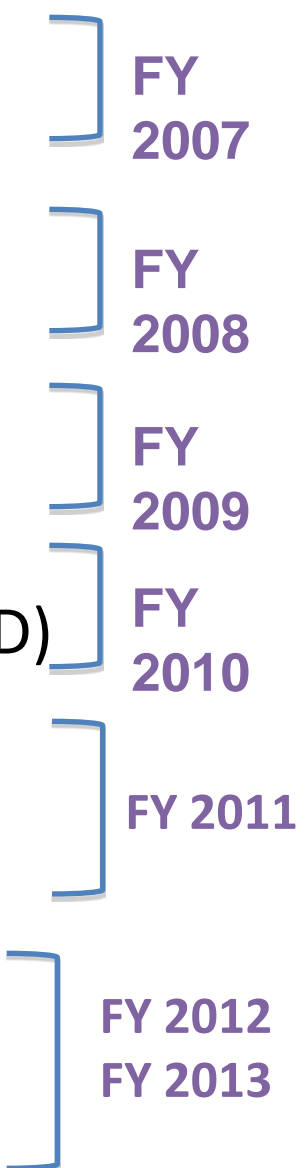
FY 2007	Auto-Reconfigurable Engineered Systems ( <b>ARES</b> ) Cellular and Biomolecular Engineering ( <b>CBE</b> )
FY 2008	Cognitive Optimization ( <b>COPN</b> ) Resilient and Sustainable Infrastructures ( <b>RESIN</b> )
FY 2009	Biosensing and Bioactuation ( <b>BSBA</b> ) Hydrocarbon from Biomass ( <b>HyBi</b> )
FY 2010	Science in Energy and Environmental Design ( <b>SEED</b> ) Renewable Energy Storage ( <b>RESTOR</b> )
FY 2011	Engineering Multicellular and Interkingdom Signaling ( <b>MIKS</b> ); Mind, Machines, and Motor Control ( <b>M3C</b> )
FY '12,'13	Flexible Bioelectronics Systems ( <b>BioFlex</b> ), Origami Design for the Integration Of Self-assembling Systems For Engineering Innovation ( <b>ODISSEI</b> ); Photosynthetic Biorefineries ( <b>PSBR</b> )
- **TOPIC LEADERS** - Program Directors from ENG Divisions in collaboration with PDs from other NSF Directorates and other Federal agencies when appropriate  
[http://nsf.gov/staff/staff\\_list.jsp?org=EFRI&from\\_org=EFRI](http://nsf.gov/staff/staff_list.jsp?org=EFRI&from_org=EFRI)
- **CONTACT** - Rosemarie D. Wesson, [rwesson@nsf.gov](mailto:rwesson@nsf.gov), (703) 292-7070.  
<http://nsf.gov/eng/efri> and <http://efri.org>

**\$32M**  
**FY 13 Request**

# EFRI Criteria

- **TRANSFORMATIVE:** Does the proposed topic represent an opportunity for a significant leap or paradigm shift in a research area, or have the potential to create a new research area? [What are the underpinning breakthroughs?]
- **NATIONAL NEED/GRAND CHALLENGE:** Is there potential for making significant progress on a current national need or grand challenge?
- **INTERDISCIPLINARY:** Does the topic require inter/multi-disciplinary expertise?

# EFRI Topics

- Auto-Reconfigurable Engineered Systems (ARES)
  - Cellular and Biomolecular Engineering (CBE)
  - Cognitive Optimization (COPN)
  - Resilient and Sustainable Infrastructures (RESIN)
  - Biosensing and Bioactuation (BSBA)
  - Hydrocarbons from Biomass (HyBi)
  - Renewable Energy Storage (RESTOR)
  - Science in Energy and Environmental Design (SEED)
  - Engineering New Technologies Based on Multicellular and Inter-kingdom Signaling (MIKS)
  - Mind, Machines, and Motor Control (M3C)
  - Flexible Bioelectronics Systems (BioFlex)
  - Origami Design (ODISSEI)
  - Photosynthetic Biorefineries (PSBR)
- 
- | Fiscal Year  | Topics  |
|--------------|---|
| FY 2007      | Auto-Reconfigurable Engineered Systems (ARES), Cellular and Biomolecular Engineering (CBE)                                      |
| FY 2008      | Cognitive Optimization (COPN), Resilient and Sustainable Infrastructures (RESIN)  |
| FY 2009      | Biosensing and Bioactuation (BSBA), Hydrocarbons from Biomass (HyBi), Renewable Energy Storage (RESTOR)                         |
| FY 2010      | Science in Energy and Environmental Design (SEED)   |
| FY 2011      | Engineering New Technologies Based on Multicellular and Inter-kingdom Signaling (MIKS), Mind, Machines, and Motor Control (M3C) |
| FY 2012-2013 | Flexible Bioelectronics Systems (BioFlex), Origami Design (ODISSEI), Photosynthetic Biorefineries (PSBR)                        |

# Sustaining EFRI Topics Post-EFRI

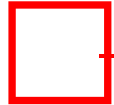
- General Ideas For Post-EFRI support:
  - CENTERS (ERCs, STCs, other)
  - NEW PROGRAMS within or across Divisions
  - RESTRUCTURED PROGRAMS at NSF
  - IDR opportunity in ENG (group interdisciplinary awards of up to \$1M; though funds are very limited)
  - OTHER AGENCIES
  - NEW EFRI TOPICS THAT MAY BE AN EVOLUTION OF AN EARLIER TOPIC
  - INTERAGENCY INITIATIVES
  - INTERNATIONAL INITIATIVES
  - Some Topics will not be appropriate for further support.



# Sustaining EFRI Topics

## Status Check

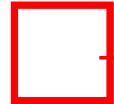
- **CBE (7 projects, FY 2007)**



- **STC AWARD TO ONE EFRI GROUP (MIT, Kamm)**

- Another is competing for STC
- Others will try for ERC or other Center programs
- NIH
- One awarded MIKS (Pruitt); Two MIKS grantees were trained by CBE PIs

- **ARES (5 projects, FY 2007)**



- **MIT-Singapore: Future of Urban Mobility**

- One in STC competition
- Cyber-Physical Systems (CPS)
- ECCS and CMMI support the technical area

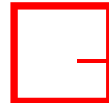
- **COPN (4 projects, FY 2008)**



- **ERC AWARD TO ONE (U. Washington, Matsuoko)**

- ECCS and CBET support the technical areas but group awards?
- Some may pursue Centers program

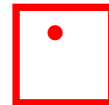
- **RESIN (8 projects, FY 2008)**



- **A RESEARCH CLUSTER IN CMMI**

- TOPIC or a variation may repeat in 2014
- An academic program at UIUC

- **BSBA (12 projects, FY 2009)**

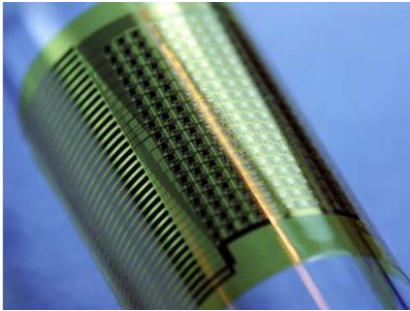


- **NEW PROGRAM IN CBET: Biosensing (Alex Simonian)**

- One PI plans to apply for Center programs

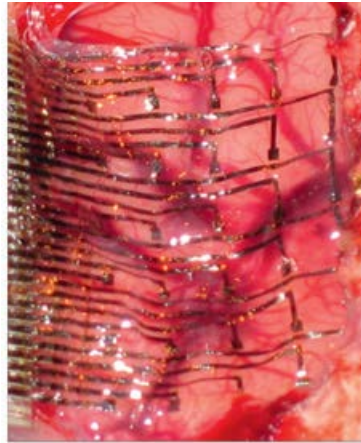
# Topic 1: BioFLEX – Flexible Electronics For Biomedical Applications

Flexible electronics

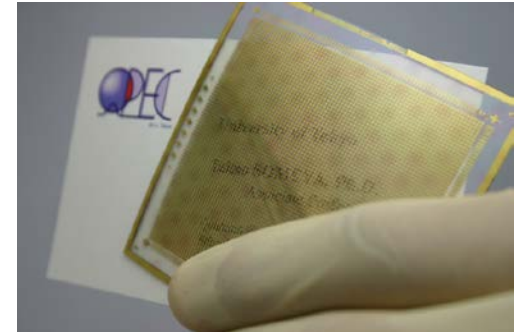


Wrap around cylindrical surface

Stretchable electronics



Flexible Scanner



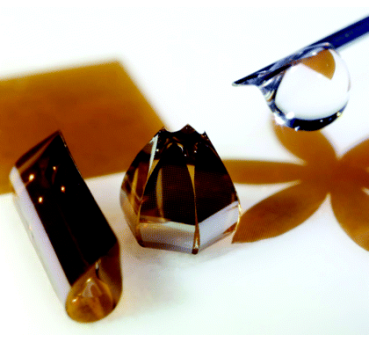
Rogers et al., “Materials and Mechanics for Stretchable Electronics”, Science 327, 1603 (2010)

## **Expected Transformative Impact:**

Advances in basic science and engineering, including materials, devices, circuit design, novel sensors, biomedical applications

Develop/focus enabling technologies that allow enhancing quality of life and patient care while lowering total healthcare costs

New collaborations between different communities (materials, electrical, biomedical, chemical, manufacturing etc.)



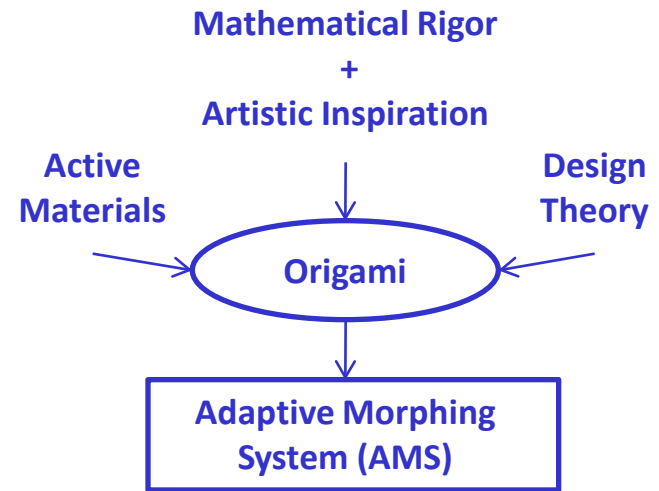
# TOPIC 2:

## FOLD: Origami Design for Integration of Adaptive Morphing Systems

**Objective:** Use origami to enable self-assembling, multifunctional, compliant structures (Adaptive Morphing Systems) through the integration of active materials, design theory and compliant mechanisms, mathematics, and artistic inspiration.

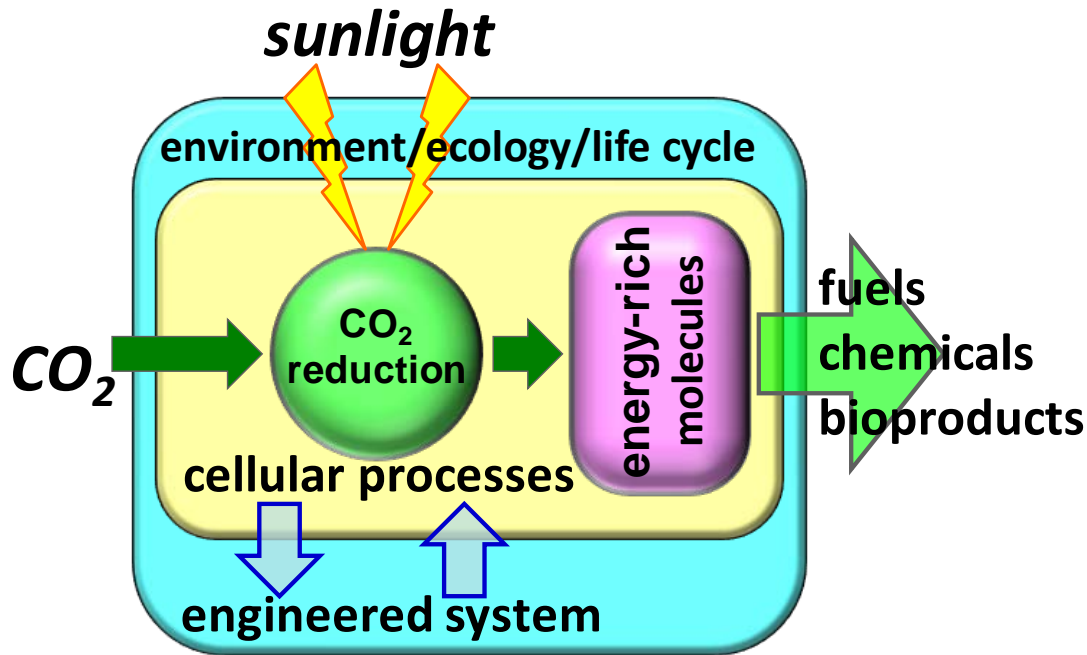
### Expected Transformative Impact:

- Foster advances in fundamental understanding of folding and unfolding mechanisms in active materials, design theory, and mathematics
- Underpin design of foldable products at all scales and across scales
- Promote new collaborations between different communities
- Enable novel engineered adaptive morphing systems for breadth of national priorities, including energy, complex design, and manufacturing



## Topic 3:

# Upscaling Photobiological Processes - The Sustainable Photosynthetic Biorefinery



**Objective:** Establish the fundamental principles which efficiently deliver light and CO<sub>2</sub> to photosynthetic micro-organisms in scalable platforms for the sustainable & flexible production of fuels, chemicals, and bio-products

### Expected Transformative Impact

- New paradigms for the rational/sustainable design and upscaling of photosynthesis-based, bio-manufacturing platforms that use sunlight and atmospheric CO<sub>2</sub> as inputs
- Advances in the basic science of flexibly transforming atmospheric CO<sub>2</sub> to complex and/or energy-rich molecules through metabolic processes
- Novel engineered systems for the emerging bio-economy