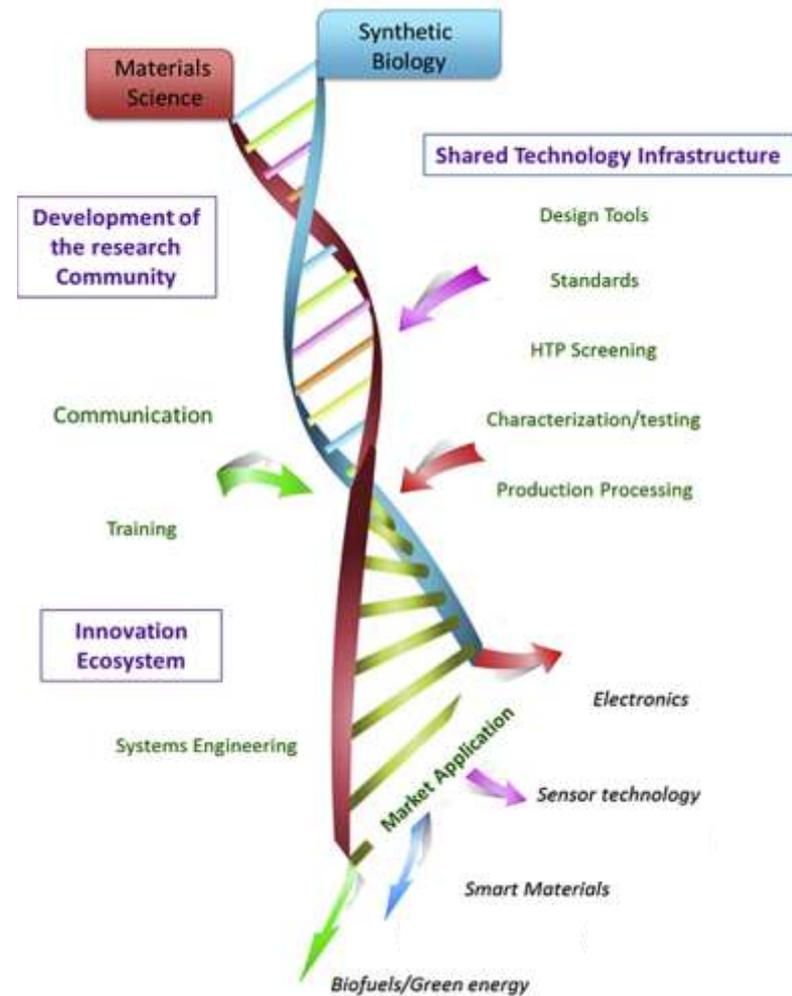


# DOE-BER Workshop: Genome Engineering for Material Synthesis (GEMS)

Seema Singh, Ph.D.  
October 18, 2018

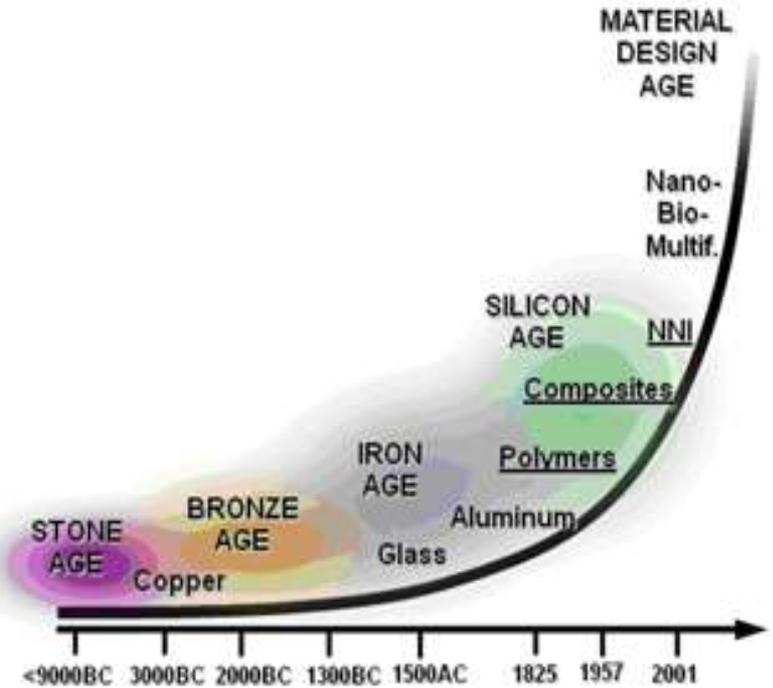
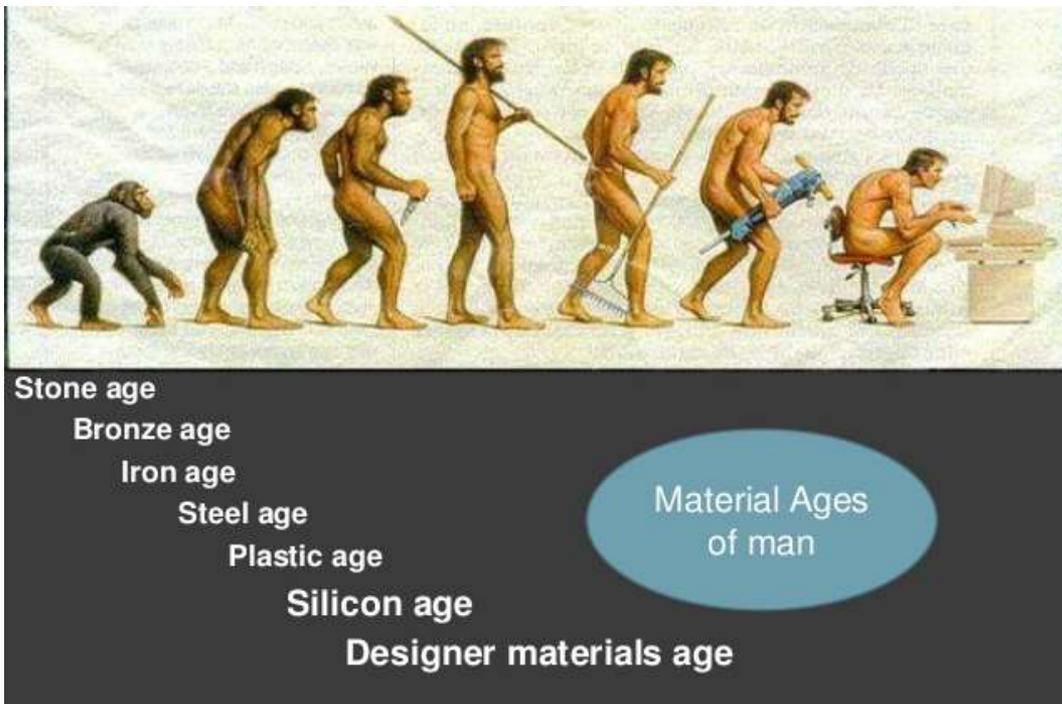


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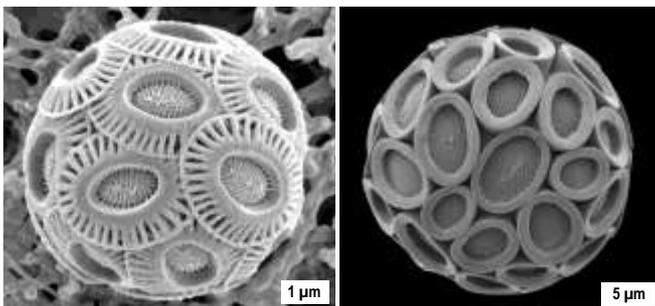
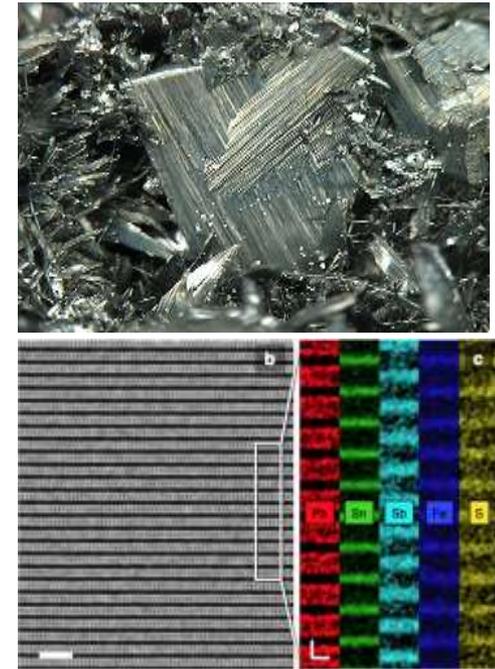
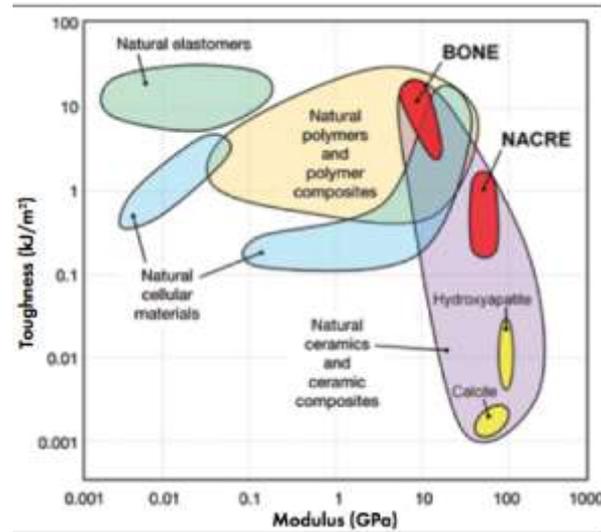
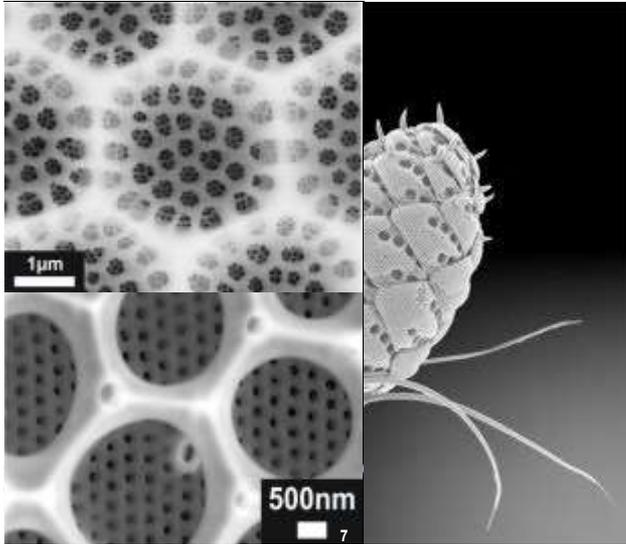
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# Materials- an important aspect of civilizations

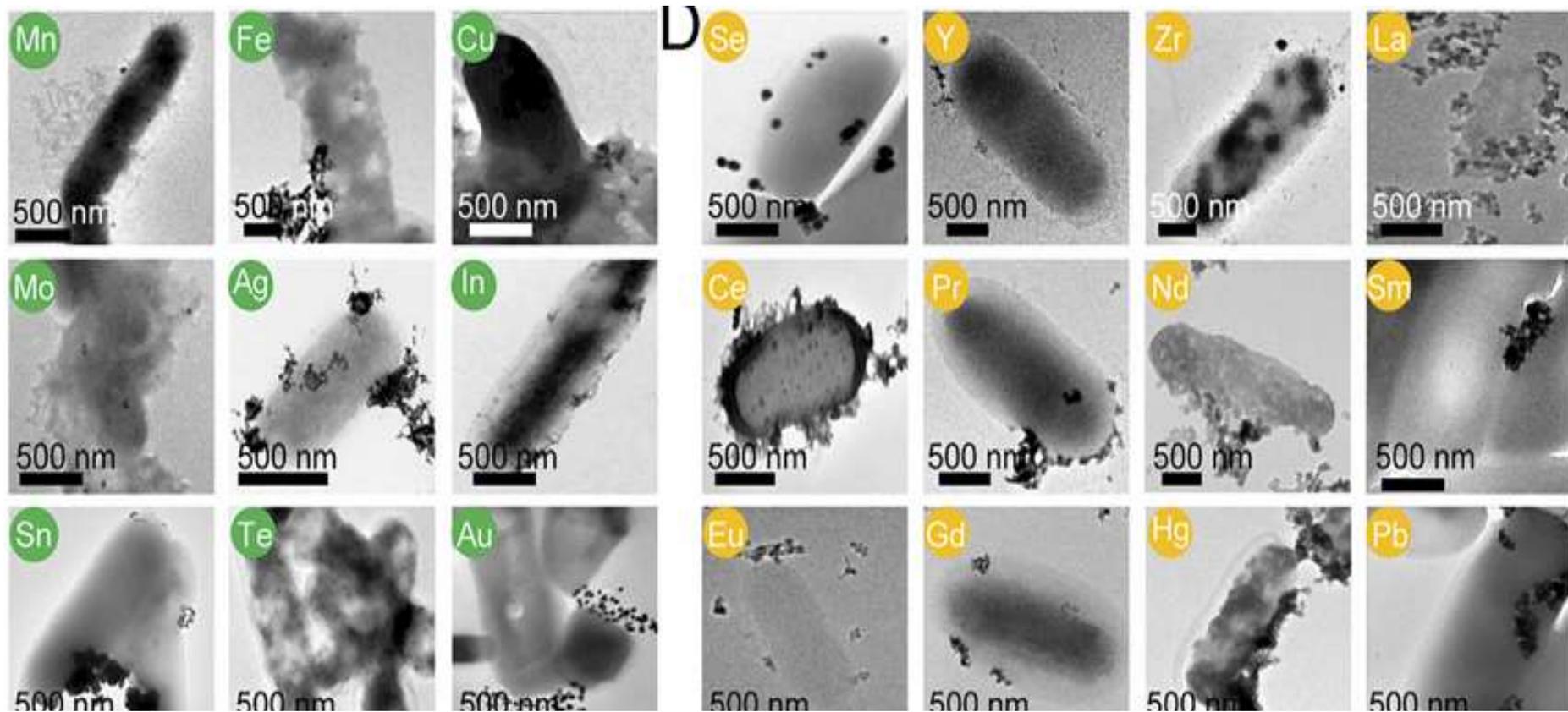


# Biomaterials as inspiration



- Ornate and hierarchical structures;
- Mild pH;
- Ambient temperatures;
- Environmentally friendly and all-aqueous (“green”);
- Controlled;
- Involvement of organic components.

# Bio-derived Inorganic Material via Synthetic Biology



<https://doi.org/10.1073/pnas.1804543115>

# *Why Genome Engineering for Inorganic/Hybrid Materials?*

- ***Augment current genome/metabolic design capabilities***
  - expand number and diversity platform pathways and/or organisms
- ***Expand genomic engineering to inorganic materials***
  - design and/or modify new genome-based mechanisms of inorganic synthesis
- ***Explore the genomic design space for organic/inorganic materials synthesis***
  - couple organic/inorganic synthesis designs
  - explore new genome-controlled materials design
- ***Explore the broader potential of natural synthesis processes***
  - mining of metagenomic data for new synthesis capabilities

# Genome Engineering for Material Synthesis Workshop

October 9-11, 2018  
Rockville, MD



# Workshop Attendees

Caroline Ajo-Franklin	LBL	co-chair
Michael Jewett	Northwestern U.	co-chair
Huimin Zhao	U. Illinois, Urbana-Champaign	co-chair
Brian Fox	U. Wisconsin, Madison	co-chair
Derk Joester	Northwestern U.	
Arash Komeili	UC Berkeley	
Claudia Schmidt-Dannert	U. of Minnesota	
Philippe Noirot	ANL	
Jay Keasling	LBL/UCB	
Filipe Natalio	Weizmann Institute	
Arpita Bose	Washington U	
Lance Stewart	U. of Washington	
Kevin Morey	Colorado State U.	
Yasuo Yoshikuni	LBL/JGI	
P.U.P.A. Gilbert	U. Wisconsin	
Olga Ovchinnikova	ORNL, Center for Nanophase Material Sciences	
Oleg Gang	Brookhaven, Columbia	
Wil Srubar	U. Colorado, Boulder	
Laurie Gower	U of Florida	
Nils Kröger	U. Dresden, Germany	
John Shanklin	BNL	
Sanat Kumar	Columbia U	
Farren Isaacs	Yale U.	

# Multi-disciplinary beautiful minds

## Biology/Synbio Expertise



## Biomaterial Expertise



## Plant Expertise

## Enabling Technologies & Computation Expertise



# Workshop Agenda

## Tuesday, October 9, 2018

7.30 – 8.00AM	Breakfast
8.00 – 8.30AM	BER welcome, introductions, overview by Dr. Todd Anderson, BER
8.30 – 9.15AM	“GEMS: Potential Scientific Opportunities” Talk and Agenda outline for Day 1(co-chairs)
9.15 – 9:45AM	Science Presentation “ <i>Biom mineralization of nacre and sea urchin spicules</i> ” Speaker: Dr. Pupa Gilbert, University of Wisconsin, Madison
9.45 – 11.45AM	<b>Breakout session #1 “Designer Inorganic Materials”</b>
11:45 – 12:45 PM	Lunch Break
12.45 – 1.15 PM	Breakout session report prep
1:15 – 2:15 PM	Summary and discussion of Breakout session #1(15 Mins each group, 15 mins Q&A)
2.15 – 2.30 PM	Coffee Break
2.30 – 3.00 PM	Science Presentation “ <i>Synthetic Biology with Protist Biominerals: The Diatom Paradigm</i> ” Speaker: Dr. Nils Kroger, Dresden, Germany
3.00 – 3.30 PM	Science Presentation “ <i>Towards genetically programmable bio composites with controllable architectures, mechanical properties and bio-functionalities</i> ” Speaker: Dr. Claudia Dannert-Schmidt, University of Minnesota
3.30 – 5.30 PM	<b>Breakout session #2 “Designer Hybrid Soft-Hard Materials”</b>
5.30 – 6.00 PM	Breakout session report prep
6.00 – 7.00 PM	Summary and discussion of Breakout session #2 (15 Mins each group, 15 mins Q&A)
7.00 – 7.30 PM	Group Discussion on Topics 1 and 2
7.30 PM	Adjourn (Dinner on your own)

# Workshop Agenda

## Cont'd

Wednesday, October 10, 2018

8.00 – 8.30AM	Breakfast
8.30 – 8.45 AM	Agenda outline for Day 2, topics, groups, B/O schedule (co-chairs)
8.45 – 9:15AM	Science Presentation “ <i>Exploring and exploiting bacterial compartments for synthetic biomineral production</i> ” Speaker: Dr. Arash Komeili, University of California, Berkeley
9.15 – 9:30AM	Coffee Break
9.30 – 11.30 AM	<b>Breakout session #3 “Designer Cell-Inorganic Materials”</b>
11.30 – 12.00 PM	Breakout session report prep
12.00 – 1.00PM	Lunch Break
1.00 – 2.00PM	Summary and discussion of Breakout session #3 (15 Mins each group, 15 mins Q&A)
2.00 – 2.30PM	Science Presentation “ <i>Towards material farming: where plant biology meets material sciences</i> ” Speaker: Filipe Natalio, Weizmann Institute of Science
2:30-3:00 PM	Science Presentation “Next-generation synthetic biology tools” Speaker: Huimin Zhao, University of Illinois Urbana/Champaign
	<i>Grab Coffee and head to breakout session</i>
3.00 – 5.00 PM	<b>Breakout session #4 Enabling characterization technologies</b>
5.00 – 5.30 PM	Breakout session report prep
5.30 – 6.15 PM	Summary and discussion of Breakout session #4 <b>Enabling Characterization Technologies</b> (15 mins per group and 15 mins Q&A)
6.15 – 7.00PM	Group Discussion on Topics 3 and 4 (and overall)
7.00PM	Adjourn (Dinner on your own)

## Breakout Session #1: Designer Inorganic Materials

1.1 (Eisenhower)	1.2 (Jackson)	1.3 (Monroe)
Jay Keasling	Farren Isaacs	Huimin Zhao
Sanat Kumar	Arpita Bose	Claudia Schmidt-Dannert
Derk Joester	Filipe Natalio	Wil Srubar
Arash Komeili	Yasuo Yoshikuni	Philippe Noirot
Olga Ovchinnikova	Lance Stewart	P.U.P.A. Gilbert
Laurie Gower	Nils Kröger	Kevin Morey
Brian Fox	John Shanklin	Oleg Gang
	Caroline Ajo-Franklin	

## Breakout Session #2: Designer Hybrid Materials

2.1 (Eisenhower)	2.2 (Jackson)	2.3 (Monroe)
Derk Joester	P.U.P.A. Gilbert	Brian Fox
Laurie Gower	Arash Komeili	Nils Kröger
Filipe Natalio	Oleg Gang	Caroline Ajo-Franklin
Yasuo Yoshikuni	Sanat Kumar	Wil Srubar
Huimin Zhao	Jay Keasling	John Shanklin
Claudia Schmidt-Dannert	Arpita Bose	Kevin Morey
Lance Stewart	Lance Stewart	Olga Ovchinnikova
Farren Isaacs		

## Breakout Session #3: Designer Cell-Inorganic Materials

3.1 (Eisenhower)	3.2 (Jackson)	3.3 (Monroe)
	Caroline Ajo-Franklin	Philippe Noirot
Filipe Natalio	John Shanklin	Kevin Morey
Wil Srubar	Arash Komeili	Brian Fox
Huimin Zhao	Oleg Gang	Derk Joester
Sanat Kumar	Jay Keasling	Lance Stewart
Yasuo Yoshikuni	P.U.P.A. Gilbert	Claudia Schmidt-Dannert
Nils Kröger	Arpita Bose	Farren Isaacs
Olga Ovchinnikova	Laurie Gower	

## Breakout Session #4: Techniques

4.1 Instrumentation (Eisenhower)	4.2 Bio tools/Methodology (Jackson)
Olga Ovchinnikova	Yasuo Yoshikuni
Oleg Gang	Lance Stewart
Derk Joester	Wil Srubar
Arash Komeili	Nils Kröger
Filipe Natalio	Arpita Bose
Sanat Kumar	Laurie Gower
Claudia Schmidt-Dannert	Huimin Zhao
P.U.P.A. Gilbert	Jay Keasling
Philippe Noirot	Brian Fox
Kevin Morey	John Shanklin
Caroline Ajo-Franklin	Farren Isaacs

Breakout Sessions & Report out

# Workshop Charge Summary

- What kinds of inorganic or inorganic-organic hybrid materials can be made now?
- What other materials could you envision synthesizing biologically?
- Why would you want to do this? What for?
- How would you do it? What would you need to do it?

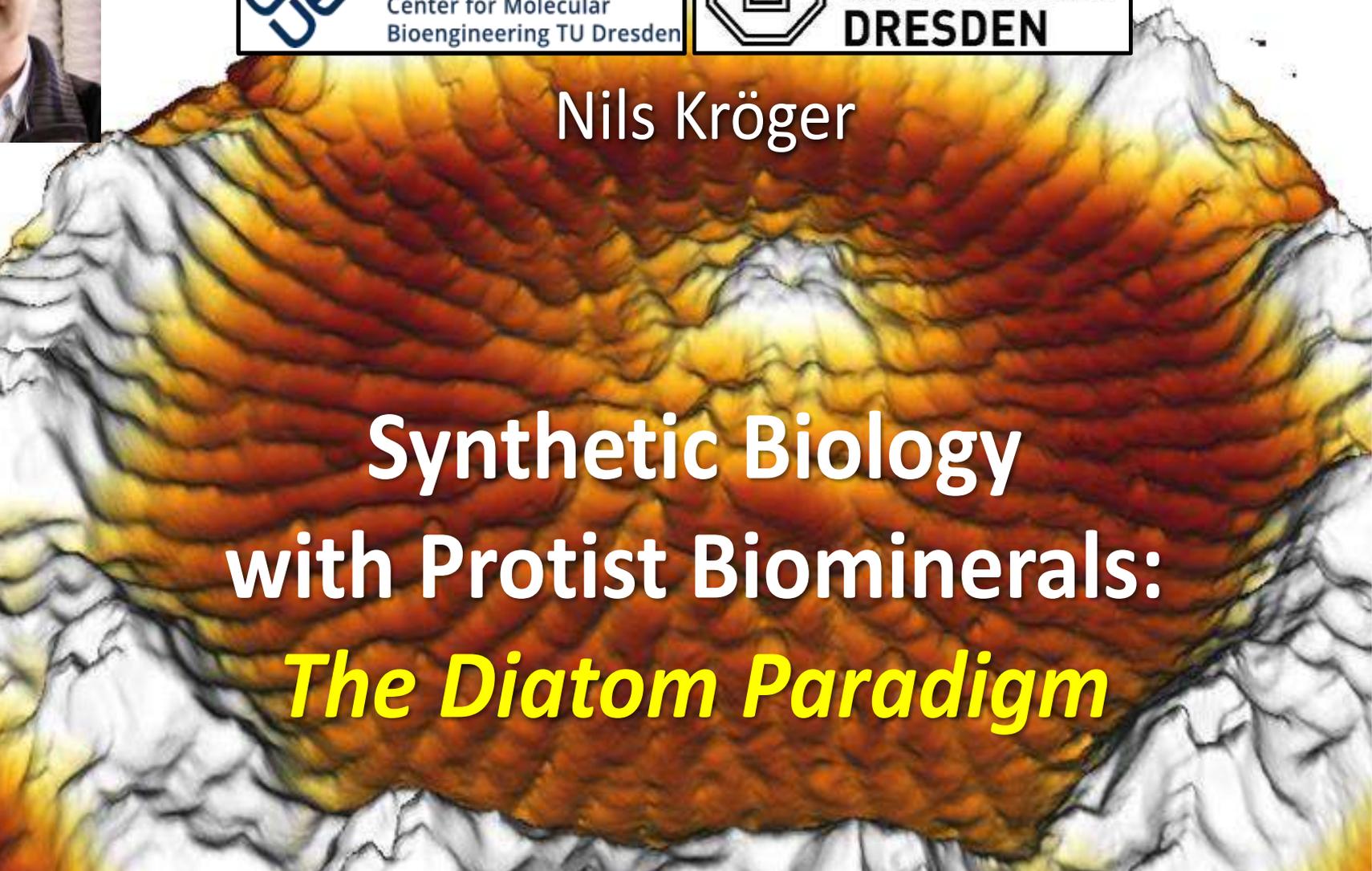
# Biomining of nacre and sea urchin spicules



Pupa Gilbert  
Departments of Physics (100%),  
Chemistry (0%),  
Materials Science (0%),  
Geoscience (0%)  
UW-Madison



Nils Kröger

A detailed microscopic image of diatom frustules, showing intricate, layered, and wavy patterns in shades of yellow, orange, and red, with white outlines representing the individual cells.

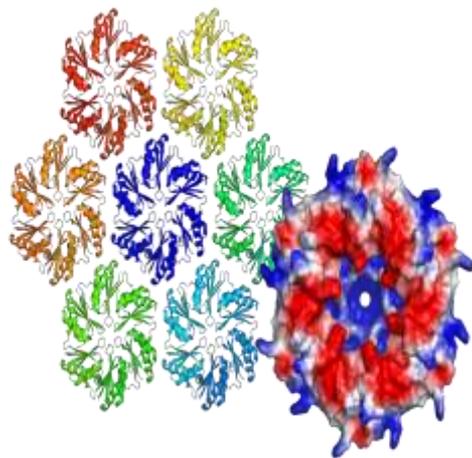
**Synthetic Biology  
with Protist Biominerals:  
*The Diatom Paradigm***



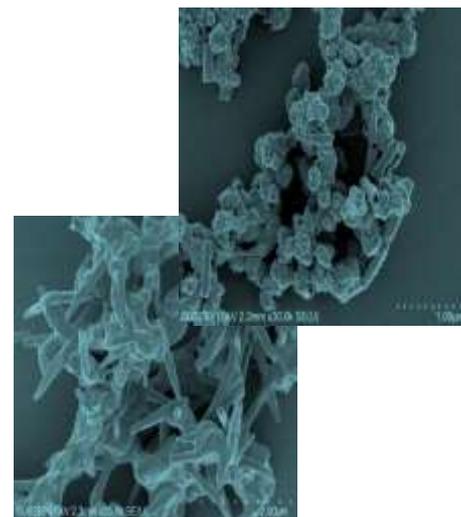
*Genome Engineering for Materials Synthesis Workshop*

***Towards genetically programmable biocomposites  
with controllable  
architectures, mechanical properties and bio-functionalities***

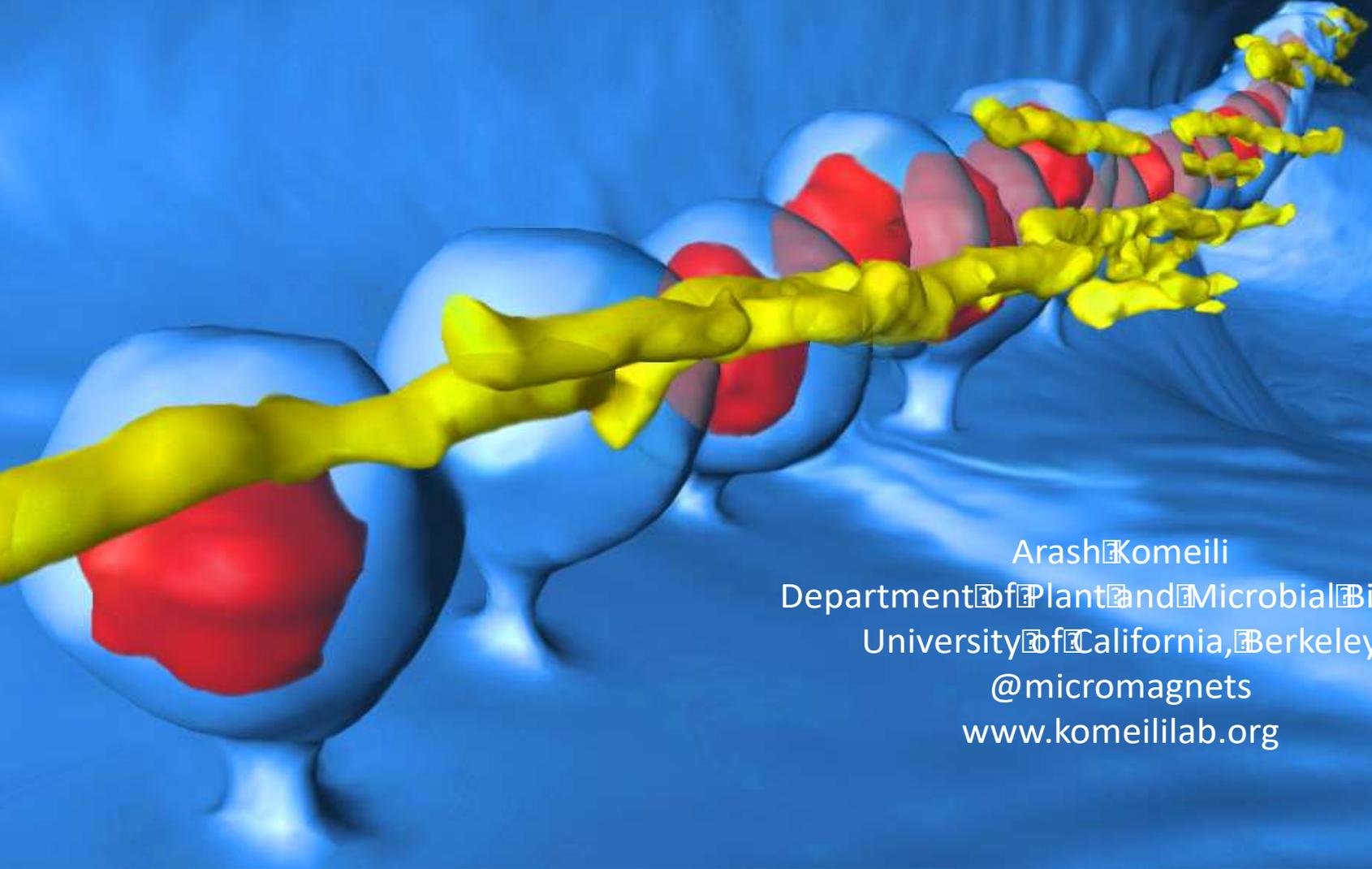
***Claudia Schmidt-Dannert***



UNIVERSITY OF MINNESOTA



# The Making of a Magnetic Microbe



Arash Komeili  
Department of Plant and Microbial Biology  
University of California, Berkeley  
@micromagnets  
[www.komeililab.org](http://www.komeililab.org)



U.S. Department of Energy's 2018  
Genome Engineering for Material Synthesis  
(GEMS) workshop

biomineralization and biological fabrication

Filipe Natalio

Department of Plant and Environmental Sciences  
Kimmel Center for Archaeological Sciences  
Weizmann Institute of Science

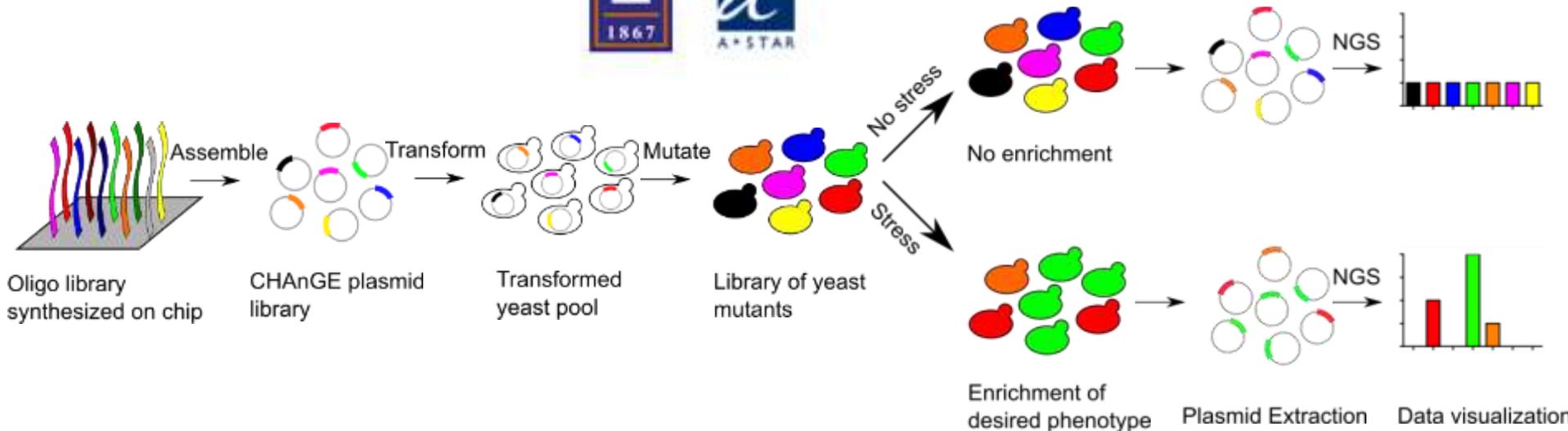


# Next-generation Synthetic Biology Tools



Huimin Zhao

University of Illinois at Urbana-Champaign  
Agency for Science, Technology and Research, Singapore



# *Workshop Agenda Cont'd*

*Attendance by Co-Chairs and Writing Team Only*

Thursday, October 11, 2018

8.00 – 8.30 AM	Breakfast
8.30 – 10.30 AM	Writing Team organization and summaries
10.30 – 10.45 AM	Coffee Break
10.45 – 12.30 PM	Working Lunch
12.30 – 1.30PM	Summary prep, additional writing assignments etc.
1.30 PM	Adjourn

## **Draft Report Outline**

Executive Summary

Introduction

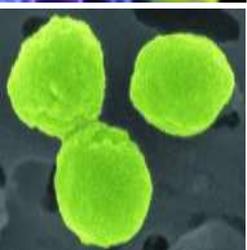
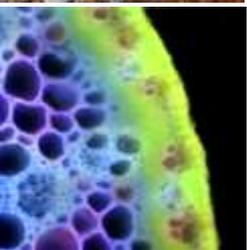
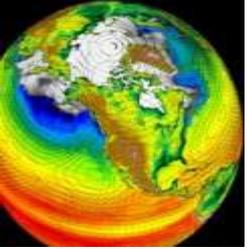
Background: Types of Genetically-Encoded Materials

Basic Science Opportunities for Genetically-Encoded Materials: What are current knowledge gaps?

Basic Science Opportunities for GEMS: What are the technology gaps?

Scientific Opportunities: What materials should we make and why?

Summary



*Stay tuned...*

**Report expected in December**

**Thank you!**



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