Graduate Program Overview

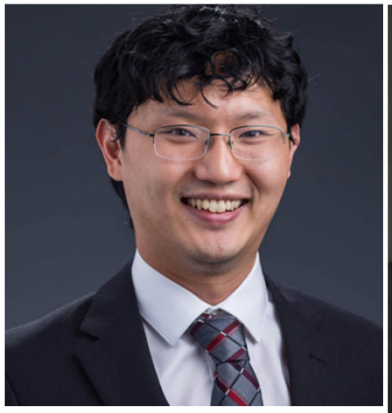
Chemical and Biomolecular Engineering

Spring 2024

Introducing our colleagues in attendance

Ms. Connie Knight
Graduate Program Coordinator

Ms. Dan Shen
Graduate Program Coordinator



Prof. Xiao Su

Prof. Chris Rao
Department Head

Prof. Alexa Kuenstler

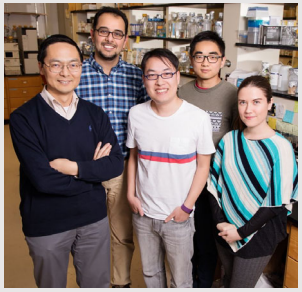
Prof. Diwakar Shukla

Ms. Patricia Simpson
Director of Career Services

Ms. Tepora Su'a
Asst. Director of Diversity, Equity & Inclusion in SCS

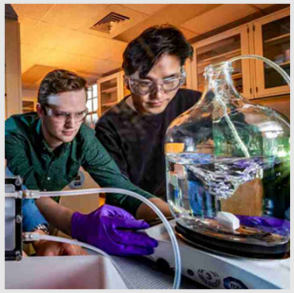
Five reasons to join Illinois:

1



Work with exceptional, collaborative and diverse faculty and students.

2

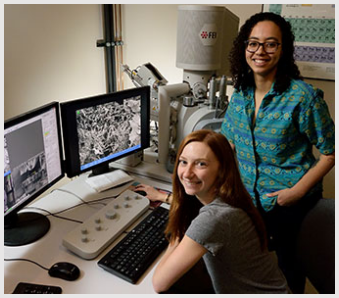


Join innovative, high-impact research in health, energy, and environment.

3

Access expertise and equipment via multidisciplinary institutes for supercomputing, genomics, AI, etc.

4



Be a part of our top ranked graduate program with world-class graduate training opportunities.

5

Live in one of the best, most affordable college towns in America.

The PhD Program in Chemical and Biomolecular Engineering

ILLINOIS

Graduate Student Stipend & Benefits

- Stipend is at least $34,858 per year
- Tuition is waived
- Some fees, including health coverage and student activity fees paid by students (~$600/semester)
- Guaranteed support while in good academic standing and making satisfactory progress toward your PhD

Advisor Selection Process

Aug. — early Sep.

Faculty present their available research projects.

2-3 weeks

Students meet with faculty and research groups individually.

end of Sept.

Students submit ranked list of advisor selections to department.

Faculty submit feedback to Department Head.

about Oct. 15

Department Head makes assignments.

*Student preferences are very important.

Course Requirements

- Total of 8 graduate courses
  - Applied Math
  - At least 3 of the following 4 topics
    - Kinetics or Rxn. Eng.
    - Thermodynamics
    - Fluids
    - Mass/Heat Transport
  - At least 500-level non-ChBE
  - "Bio" course
- Set of courses approved by DGS & advisor
  - Take 3 or 4 courses in 1st semester
  - Remainder over next 2-4 semesters
  - Students with a MS in ChemE only need to take 5 courses

Strong focus on original research

We train *original*, *independent*, and *creative* researchers

Chemical & Biomolecular Engineering

Teaching Requirements

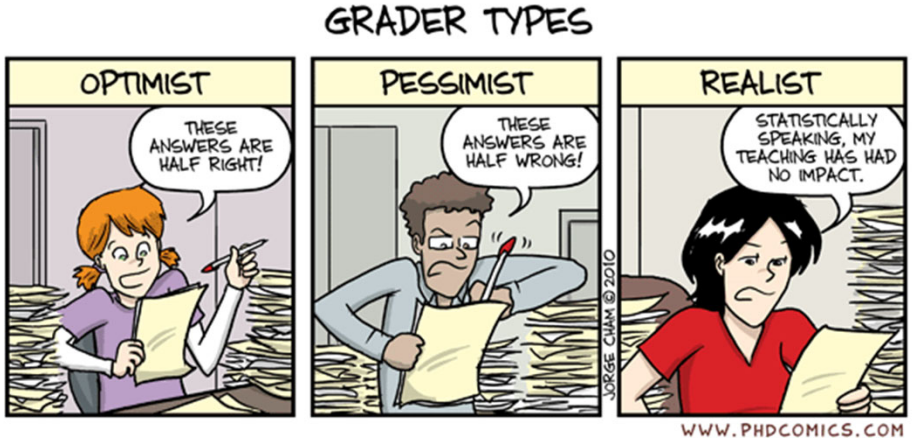
Students TA for 2 or 3 semesters
NSF, DOE etc fellows may have one semester waived

Teaching is an educational requirement for a Ph.D.
Training for future career (academia and industry)

- **TA duties involve**

✓ Grading
✓ Office hours
✓ Discussion section (possible)

- **TA time < 10 hrs/week**
- **Selection process for TAs**



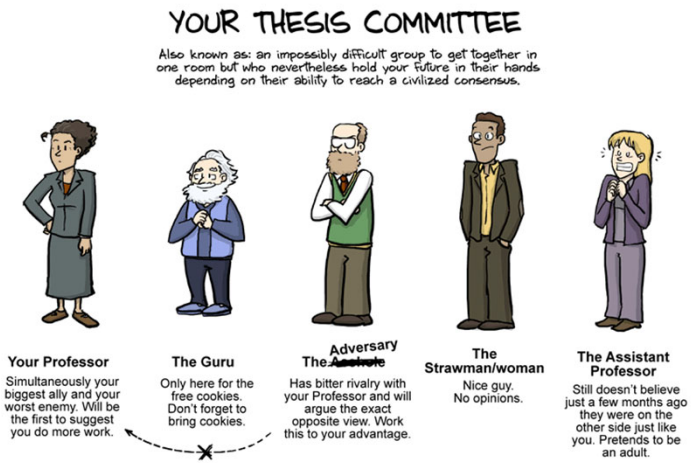
Milestones of your graduate study

Research qualifying exam:

- Taken following summer of 1st year (~late August)
- 20 min presentation + 10 min of questions with committee of faculty

Preliminary exam:

- Oral presentation to thesis committee (your advisor, 2 CHBE faculty, 1 faculty from outside ChBE)
- Present research accomplishments and plan to finish thesis
- Taken during third year of Ph.D.
- Provides a checkpoint to identify difficulties and alternatives



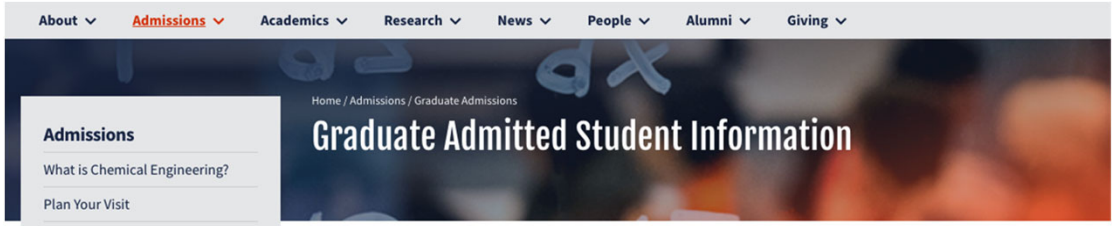
PhD Thesis and Final Defense

✓ Write your thesis
✓ Formal public presentation & questions
✓ Deposit your thesis with the Graduate College

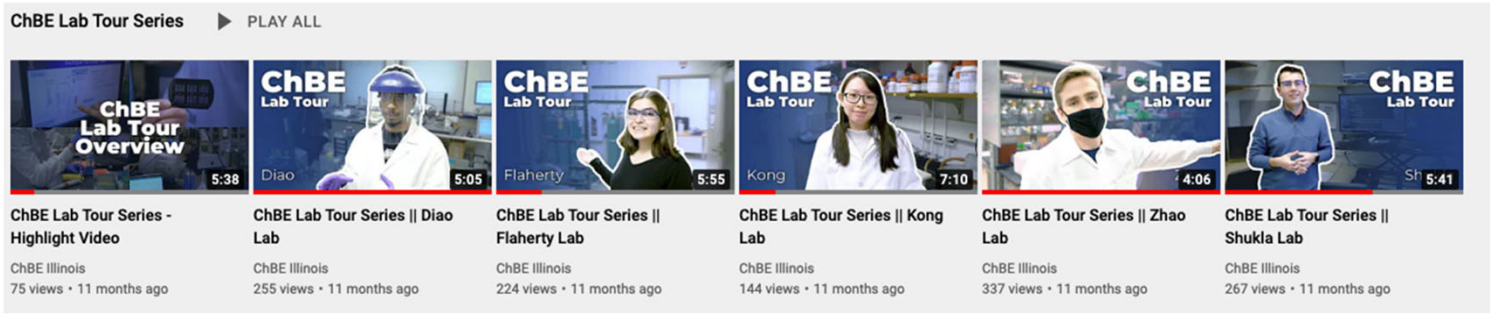
Timeline: most students graduate in 4.5 to 5.5 years

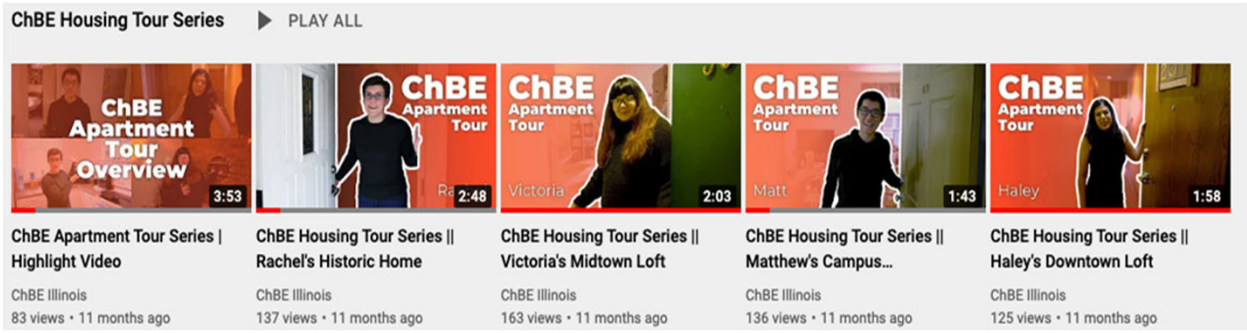
Resources for more information…

1) go.chbe.illinois.edu/AdmittedPhD



2) YouTube channel: ChBE Illinois





We are excited for your visit!

Did not have time to present this slide during the virtual visit

Life on Campus and in Urbana - Champaign

ILLINOIS

Urbana-Champaign:
One of the best college towns in America

Urbana-Champaign:
~140,000 people

Metro-area:
~250,000 people

- **#2 Best College Town In America List (2017)**
- Great food, entertainment, nightlife
- Performing arts, Krannert Center
- Recreations – campus facilities, rock gyms, trails, parks etc.

- Easy transportation
  - Can get anywhere in ~15 minutes
  - Bike, bus or walk to work - free buses

Did not have time to present this slide during the virtual visit

Affordable Housing

- 1 bedroom apartments ~$700/month
- 2 bedroom apartments ~550/month/room
- 3 bedroom apartments ~400/month/room
  - See ChBE-GSAC handout for more info

All within 1-2 miles of the Roger Adams Lab (chemical engineering building) and on bus lines

2BR/1BA, 912 sq ft
$125,000 = ~$432 per person

3BR/2BA, 1,481 sq ft
$164,900 = ~$410 per person

3BR/2BA, 1,921 sq ft
$179,000 = ~$445 per person *From Zillow*

Did not have time to present this slide during the virtual visit

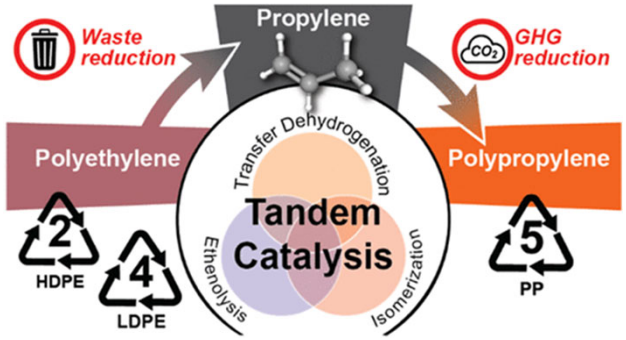
Energy and Sustainability

Grand Challenges in Energy & Sustainability

Urgent environmental problems, new feedstocks, and a sea-change for what ChemEs do with catalysis, reaction engineering, and separations!

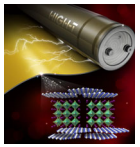
Polymer Upcycling

Peters, Guironnet



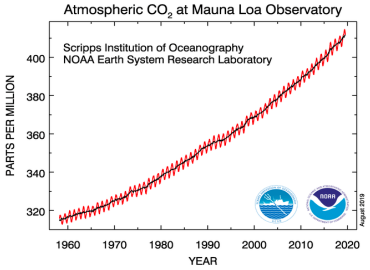
Energy Storage

Schoetz, Braun



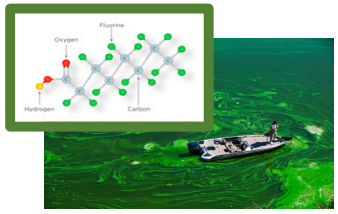
Climate Change and Greenhouse Gas Mitigation

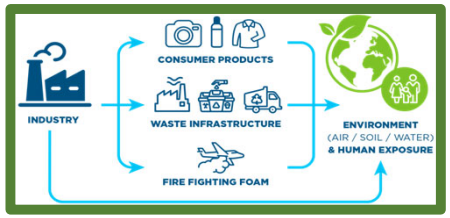
Kenis, Kuenstler, Yang



Water Purification and Environmental Remediation

Su, Mironenko, Shukla





Sustainable Fuels, Chemicals, Biorenewables

Mironenko, Peters, Guironnet

Electrified Chemical Manufacturing, Coupling with the Grid

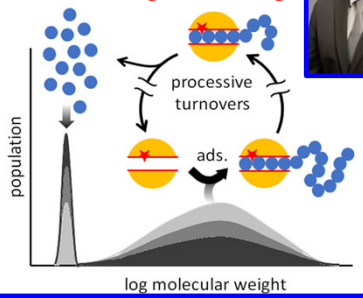
Kenis, Yang, Braun

Research in Energy & Sustainability

Interatomic Forces (Fundamentals)

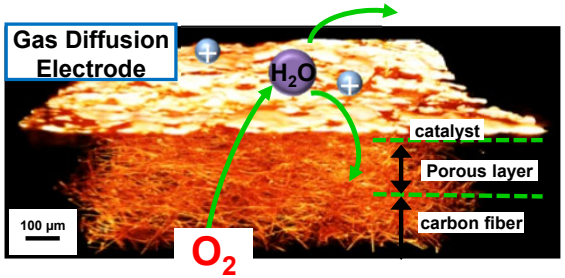
Catalysis (Fundamentals)

Bond making/breaking



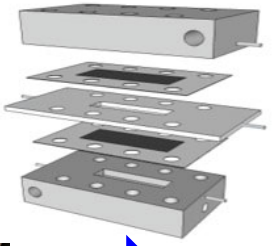
New Materials, Electrodes, Reactions (Proof of Principle)

Linking Structure and Performance

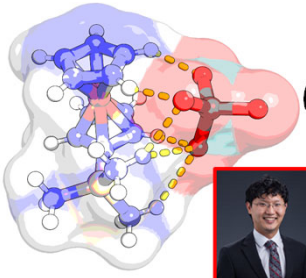


Separation / Conversion Processes (Technology)

Design and Operation

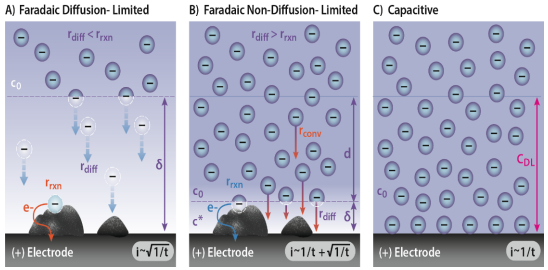


Electronic/Atomic/Molecular Scale → ***Materials Design*** → ***Systems Integration***



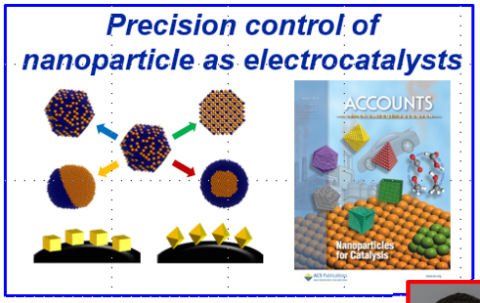
Energy Storage (Fundamentals and beyond)

Tailoring storage density, stability



Separations (Fundamentals)

Interfacial Binding



Electrocatalyst Design

Tailoring Shape and Function

Pursuing breakthroughs from molecular-scale design to system-level application…

Major Research Partnerships in EnSus

I²CNER International Institute for Carbon Neutral Energy Research

World Premier Institute (WPI), partnership of Kyushu University, Fukuoka – Japan with UIUC here in USA. Profs. Kenis, Gewirth, Sofronis, Ertekin, Perry, …

- CO_2 capture and conversion
- Solid oxide fuel cells
- Hydrogen storage and transport

Dow University Partnership Initiative

ChBE: Profs. D. Guironnet, X. Su, S. Rogers, P. Kenis
Collaborators: Profs. Rauchfuss, Girolami, Shim, …

- Renewable chemicals, upcycling plastics, new materials
- Autonomous / Automated reactors for quantum dot synthesis
- Cooperative efforts with Dow researchers

Energy and Biosciences Institute

Partnership with UC Berkeley *(Prof. Rao Associate Director)*

ChBE: Profs. P. Kenis, D. Guironnet, H. Yang, C. Rao, X. Su
Others: Profs. Rodriguez-Lopez, Gewirth…

Energy Biosciences Institute

- Chemistry and engineering for a carbon neutral future
- CO_2 reduction, green oxidants, “circularity”
- Ammonia for hydrogen transport

bp ICAM

bp

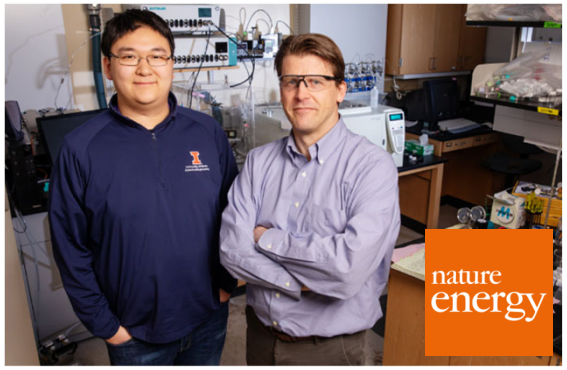
ICAM International Centre for Advanced Materials

Industry-Academia partnership between BP and UIUC, Imperial, Manchester, … UIUC: Kenis, Gewirth, Sottos, Braun, …

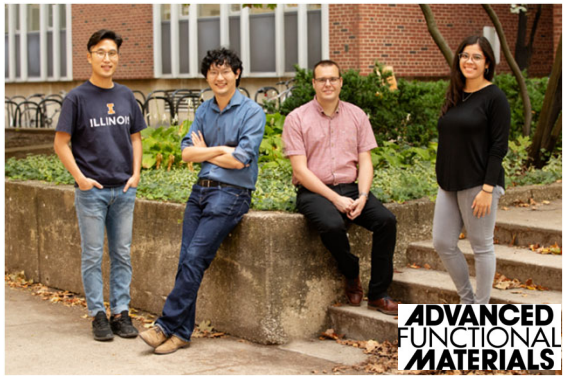
- Energy storage materials
- Water electrolysis

Faculty & Student Achievements

Reducing energy required to convert CO_2 waste into valuable resources



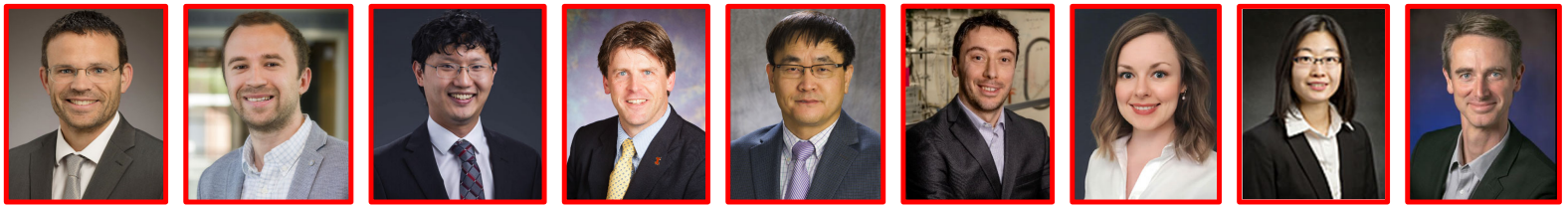
Copolymer helps remove pervasive PFAS toxins from environment



New, highly stable catalyst may help turn water into fuel

Scientists crack upcycling plastics to reduce greenhouse gas emissions

Faculty in Energy & Sustainability (All Awesome!):



Peters Mironenko Su Kenis Yang Guironnet Schoetz Diao Braun

Award-Winning and Successful Students

A few of many examples:

Jason Adams
NSF GRFP

Saket Bhargava
Link Energy Fellow,
Mavis Fellow

Daniel Bregante
DOD NDSEG, ARCS Fellow
Dissertation Completion Fellow, Mavis Fellow

Paola Baldaguez Medina
NSF GRFP
Sloan Fellowship

Claudia Berdugo Diaz
International PhD Fellows Program
SWE Rising Star Award

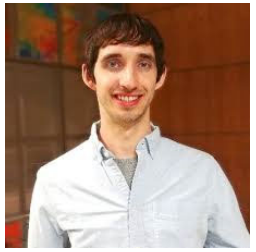
Richa Ghosh
NSF GRFP
SURGE Fellow

Drew Kuhn
Mavis Fellowship, Widiger
Fellow, Cover *Energy Technology*

Uzoma Nwabara
DuPont Fellowship

Chris Torres
NSF GRFP, Grad College
Fellow, Ford Fellow (declined)

Ajit Vikram
Ullyot Fellow,
Mavis Faculty Fellow,



Dylan Walsh
Excellence in Graduate Polymer
Research (ACS POLY)
POLY Outstanding Poster

Biomolecular Engineering

Biomolecular Engineering


Harley


Kong


Kraft


Leckband


Rao


Shukla


Zhao

Biomaterials

Tissue Engineering
Stem Cells
Regenerative Biology

Imaging

Membranes
Symbiosis
Forces

Simulation

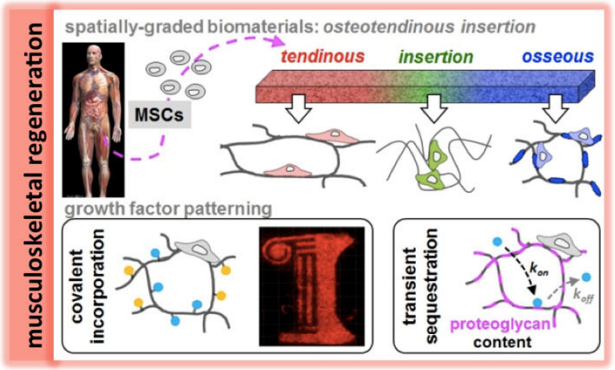
Proteins
Pathways
Cells

Synthetic Biology

Metabolic Engineering
Enzyme Engineering
Drug Design

Biomaterials for Regenerative Medicine and Drug Delivery

Harley

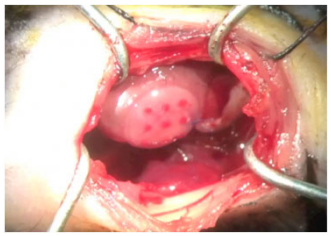


Stem Cells
Smart Materials
Implants

Regenerative Biology

(Cancer & Cyborgs)

Kong



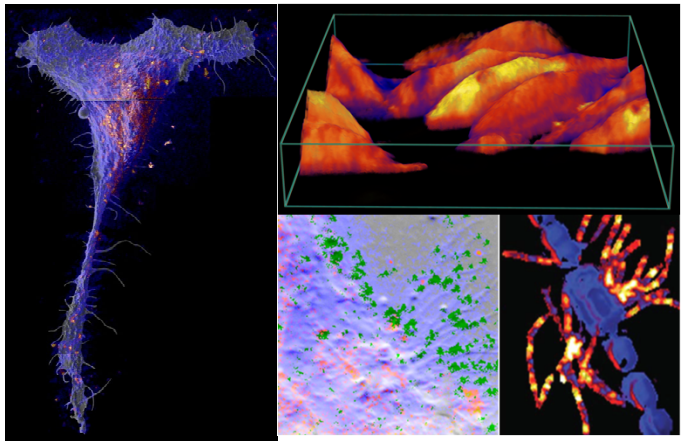
Drug Delivery
Repair, Replace,
Restore,
Regenerate

Imaging and Modeling for Healthcare, Agriculture & Biochemical Production

Kraft

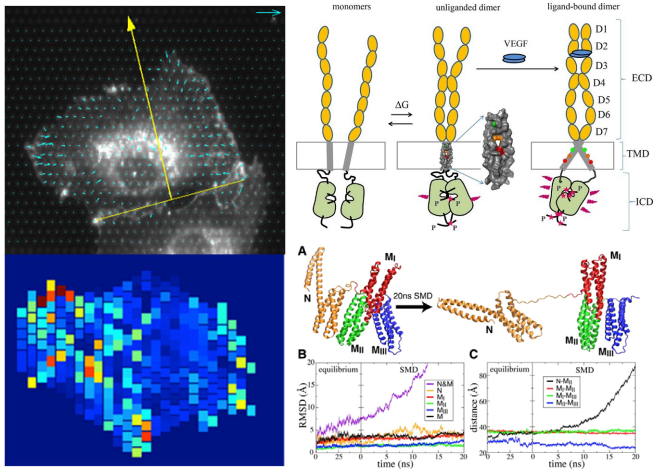
Shukla

Leckband



Chemical Imaging&
Computational Imaging
Symbiosis

Molecular Dynamics



Force Imaging
Cell-Cell Interactions

Synthetic Biology for Sustainability and Medicine

Rao

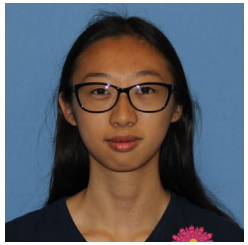
Chemicals
Fuels
Food
Nutraceuticals
Microbiome
Drugs
Enzymes
Agriculture
Precision health
Bio-computation

Zhao

Metabolic Eng.
Protein Eng.
Systems Biology
DNA Synthesis
Genomics
Metabolomics
Machine Learning
Proteomics
Bioinformatics
Robotics

Award-Winning Students in Biomolecular Engineering

Melanie Ann Brunet
NIH NRSA Individual Predoctoral Fellowship,, NIH Chemical-Biology Interface Training Grant, Multiple Poster Presentation Awards



Jiming Chen
NIH Chemical-Biology Interface Training Grant, Chia-Chen Chu Fellowshi

Aleczandria Tiffany
NSF Graduate Research Fellowship

Gunnar Thompson
Mavis Future Faculty Fellow

Chengyou Shi
Chia-Chen Chu Fellowship

Genesis Rios-Adorno
3M Corporate Fellowship
SURGE Fellowship

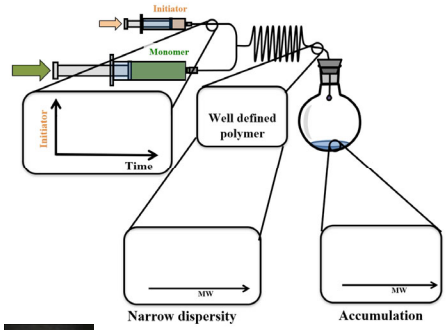
Raul Sun Han Chang
NSF Graduate Research Fellowship

Whitney Sinclair
NIH NRSA Individual Predoctoral Fellowship

Soft Matter and Advanced Materials

Building Materials from Molecules to Processes

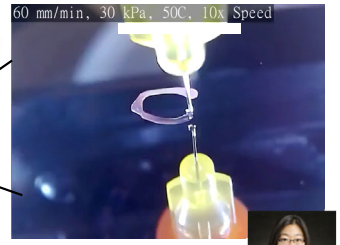
Soft and Advanced Materials: Can we engineer new materials from the molecular level, with the tools to design in desired properties?



Guironnet

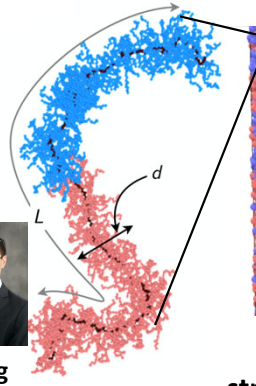
Molecular synthesis, reactor design to 'build' macromolecules

Can we use the tools of chemical engineering to create truly *complex* materials?

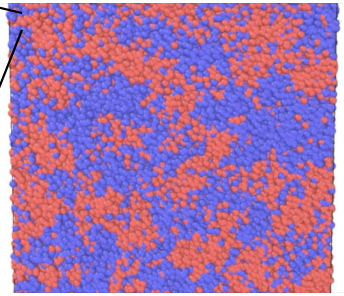


Diao

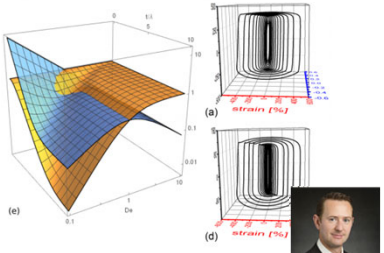
Materials processing and self-assembly to engineer emergent properties



Sing



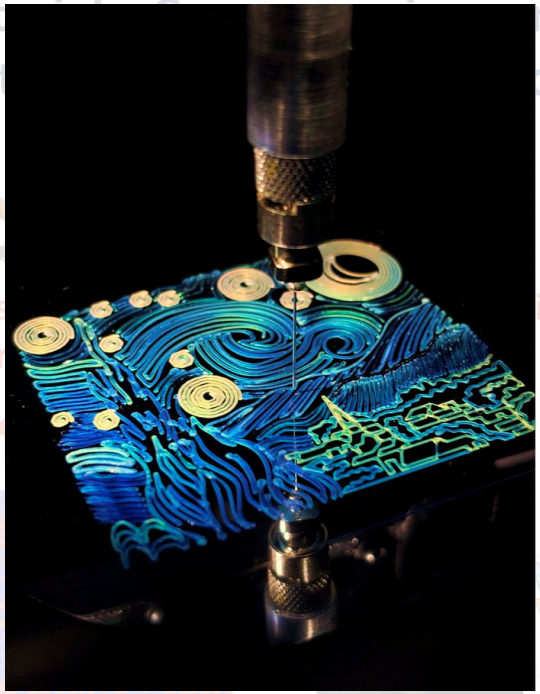
Modeling to predict structure and properties



Rogers

Characterization to understand structure, material dynamics

Building Materials from Molecules to Processes

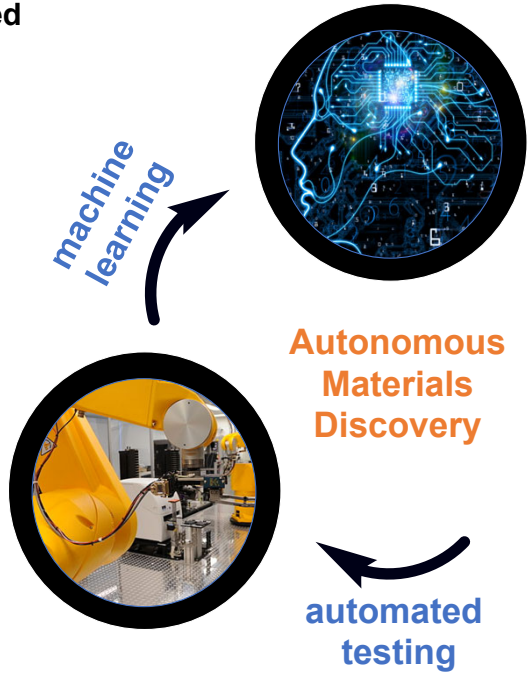


Jeon, S.; Kamble, Y.L.; Kang, H.; Shi, J.; Wade, M.A.; Patel, B.B.; Pan, T.; Rogers, S.A.; Sing, C.E.; Guironnet, D.; Diao, Y. “Direct-ink-write cross-linkable bottlebrush block copolymers for on-the-fly control of structural color.” *Proc. Natl. Acad. Sci.* **2024,** *121,* e2313617121.

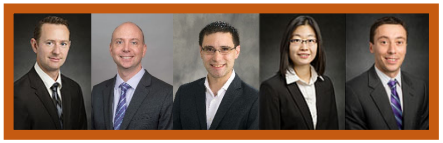
Soft and Advanced Materials Across Campus

Our team is integrated with campus-wide efforts in soft/advanced materials: collaborations with other departments such as Chemistry, MatSE, MechSE

The Beckman Institute is a hub for soft and advanced materials research across campus.



Beckman Institute: Molecular Science and Engineering theme

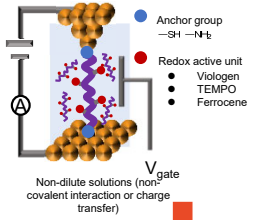


Faculty involved: Ying Diao, Charles Schroeder, Nick Jackson etc.

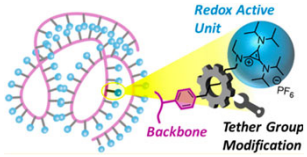
Soft and Advanced Materials Across Campus

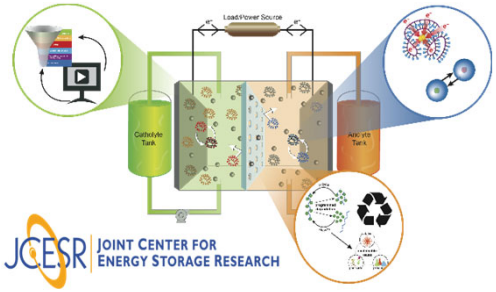
Our team is integrated with campus-wide efforts in soft/advanced materials: collaborations with other departments such as Chemistry, MatSE, MechSE

JCESR: Engineering batteries at the molecular level



The coupling between charge transport events, polymer architecture inform synthesis





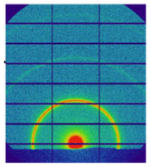
Ultimately – fundamental science combined with practical engineering to design flow batteries at the molecular level

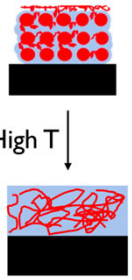
DOW UPI: Partnering with industry to inform the design of new coatings

DOW

Dow has technology they want to develop – provide materials, experience

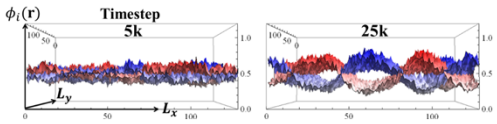
Characterize, study material structure and molecular transport

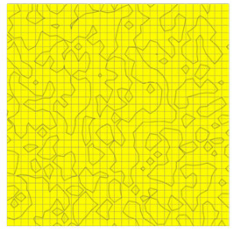




Use modeling to in concert with characterization to understand *why* structure forms, inform new material development

$$\frac{d\phi(r,t)}{dt} = M\left(f''\nabla^2\phi(r,t) + 2\kappa\nabla^4\phi(r,t)\right)$$

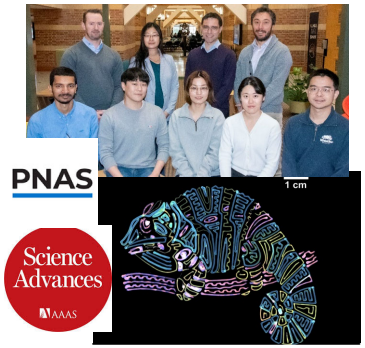




Predict formulation to yield desired morphology in industrially-relevant material systems

Impactful Faculty in Soft and Advanced Materials

Researchers mimic nature for fast, colorful 3D printing



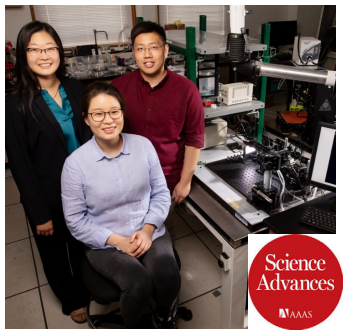
CHAMPAIGN, Ill. — Brilliantly colored chameleons, butterflies, opals – and now some 3D-printed materials – reflect color by using nanoscale structures called photonic crystals.

A new study that demonstrates how a modified 3D-printing process

Scientists crack upcycling plastics to reduce greenhouse gas emissions, advancing a recent Science study

CHAMPAIGN, Ill. – Scientists from the University of Illinois, the University of California Santa Barbara, and Dow have developed a breakthrough process to transform the most widely produced plastic – polyethylene (PE) – into the second-most

Printing flattens polymers, improving electrical and optical properties

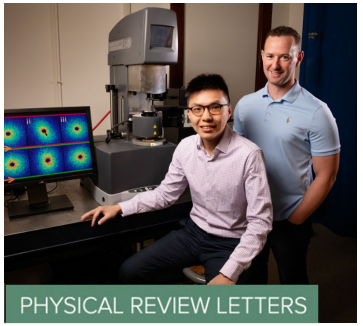


CHAMPAIGN, Ill. — Researchers have found a way to use polymer printing to stretch and flatten twisted molecules so that they conduct electricity better. A team led by chemical and biomolecular engineers from the

Electrostatic force takes charge in bioinspired polymers

CHAMPAIGN, Ill. — Researchers at the University of Illinois and the University of Massachusetts, Amherst have taken the first steps toward gaining control over the self-assembly of synthetic materials in the same way that biology forms natural polymers. This advance could prove useful

Researchers unveil how soft materials react to deformation at molecular level



CHAMPAIGN, Ill. — Before designing the next generation of soft materials, researchers must first understand how they behave during rapidly changing deformation. In a new study, researchers challenged previous assumptions regarding polymer behavior with newly developed laboratory

Faculty

Diao Sing Rogers Guironnet Kuenstler Higdon Schroeder Chen

Affiliated Faculty

Statt Evans Jackson

Award-Winning, Impactful Students in Soft and Advanced Materials

We are proud to have successful students, whose impactful research and leadership has been well recognized! A few of many examples:

Jiachun Shi
Speaker Coordinator for weSTEM2023
WE22 Poster Competition Finalist

Austin Lomas
Sloan Fellowship
Graduate College Fellowship

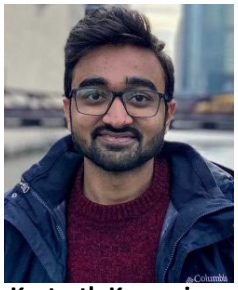
Tsai-Wei Lin
Excellence in Graduate Research
AIChE Area 08A
APS DPOLY Padden Award Finalist

Susannah Miller
Best presentation at GSAC Symposium

Azzaya Khasbaatar
A.T. Widiger Fellowship
3M Corporate Fellowship
Winner of SCS Science Image Challenge

Dejuante Walker
GEM University Fellow
Sloan Fellowship

Yash Kamble
Mavis Future Faculty Fellow
A.T. Widiger Fellowship

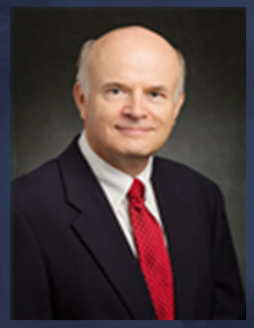


Krutarth Kamani
1st Place Poster Prize at Society of Rheology (2022)
Mavis Future Faculty Fellow

Computation and Data Sciences

Computational Chemical and Biomolecular Engineering Research Area

Prof. Higdon



Fluid Mechanics

Prof. Peters

Chemical Kinetics

Prof. Sing

Soft Matter

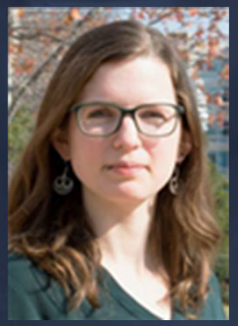
Prof. Shukla

Biophysics

Prof. Mironenko

Quantum Mechanics

Prof. Statt

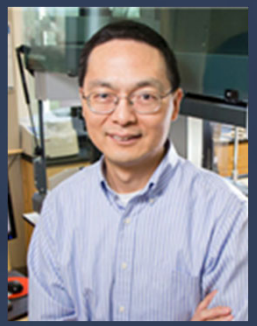


Soft Matter

Prof. Jackson

Soft Matter

Prof. Zhao



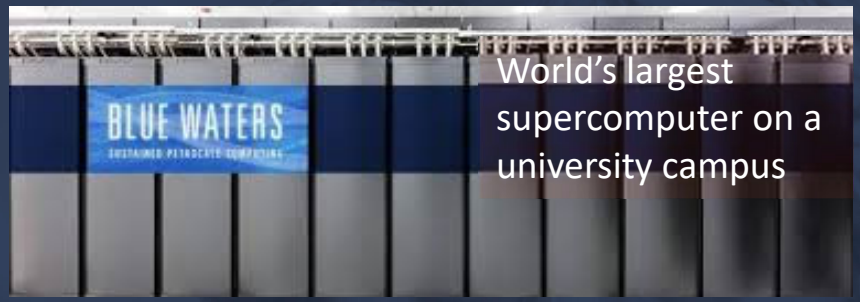
Bioengineering

Prof. Bhargava

Bioimaging

ILLINOIS

Illinois is a hub for Computational & Theoretical Research



NSF AI Institute

MOLECULE MAKER LAB INSTITUTE

THEORETICAL *and* COMPUTATIONAL BIOPHYSICS GROUP

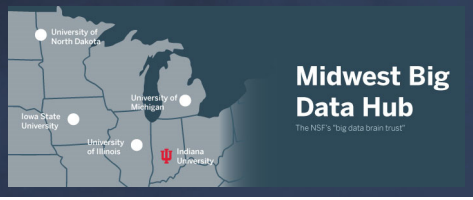
Center for the Physics of Living Cells

NAMD Scalable Molecular Dynamics

VMD

NCSA

ILLINOIS



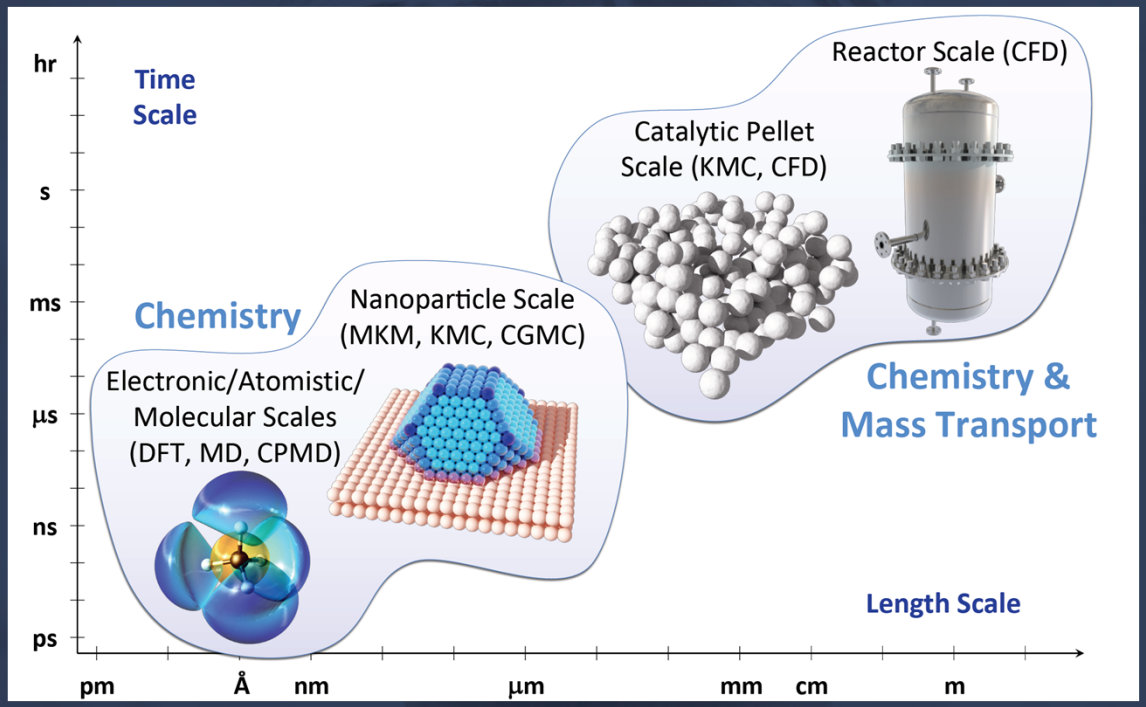
Midwest Big Data Hub

The NSF's "big data brain trust"

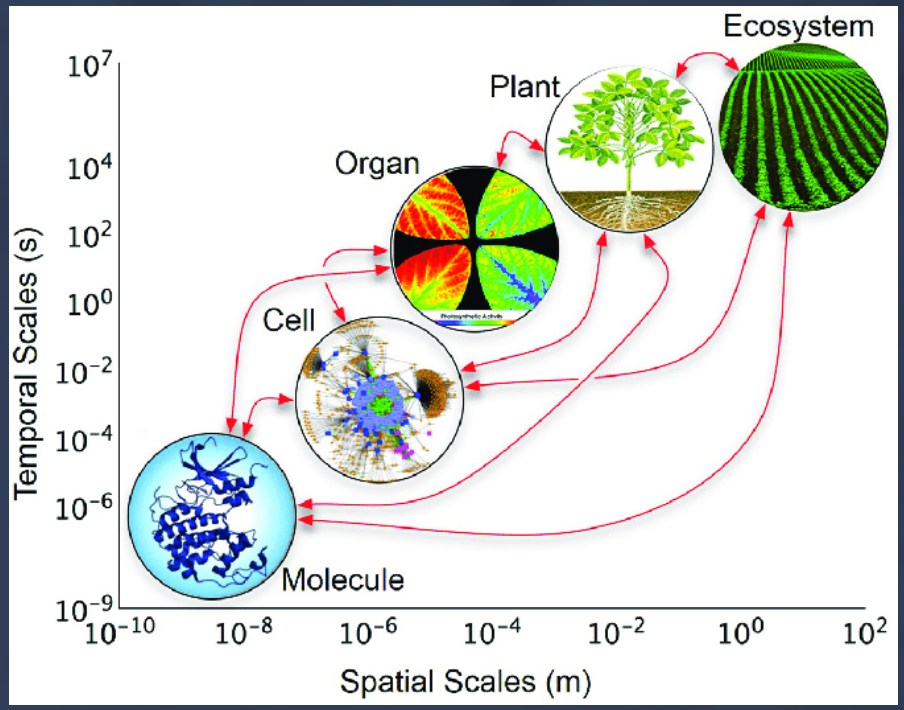
Beckman Institute

iCOUP

Why Illinois is a hub for Computational & Theoretical Research ?



Chemical systems



Biomolecular systems

ILLINOIS

Need interdisciplinary tools to bridge these length and timescales

Why Illinois is a hub for Computational & Theoretical Research ?

ILLINOIS

Illinois is a model for cross-disciplinary excellence in research