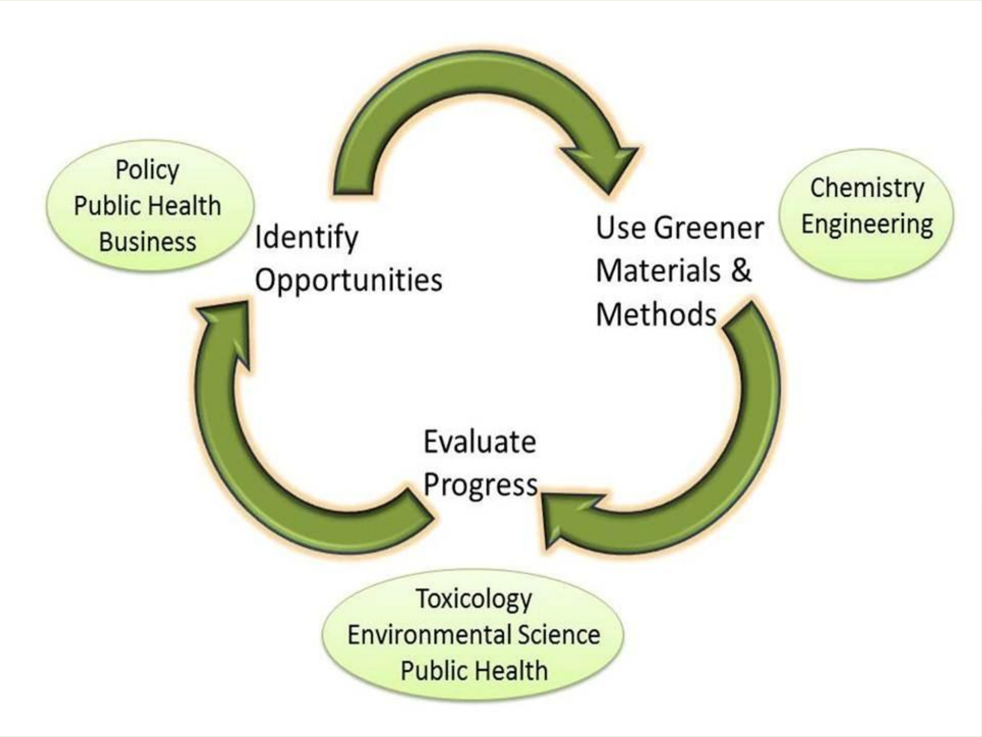
SAGE Systems Approach to Green Energy

Open House, October 8th

1. Program Overview
2. Application Process
3. Research Opportunities

Program Goals



Collaborate across disciplines.

Discover cleaner technologies.

Contribute to a systems approach that recognizes the technical, social, environmental, economic, and political factors that contribute to the adoption of new technologies.

Learn more at:
http://sage-bcgc.berkeley.edu/

Fellowship Benefits

- Students will receive a 2 year $30,000 stipend from NSF.
- In addition to receiving funding, SAGE fellows will also have the opportunity to collaborate with our international partners, initiate new interdisciplinary research projects, and work with our off-campus partners.
- Students who are awarded this fellowship will get the opportunity to work with graduate students and professors from across campus who are interested in bringing about a more sustainable energy future.

Training Overview

- *Interdisciplinary Introduction to Green Chemistry (234)*: Students will take a 3 unit, project-based, introduction to green chemistry.
- *Interdisciplinary Team Projects:* During the students' 2nd and 3rd years, they will work in interdisciplinary teams to complete projects relating to their research theme: biofuels, solar energy, or energy storage.
- *Core competency coursework:* During the 1st and 2nd years, students will complete 3 courses or graduate seminars outside their primary discipline that relate to their research theme or field of study. Examples of acceptable courses are included at the bottom of the page.
- *Green Chemistry and Sustainable Design Seminar Series*: All students will participate in this weekly seminar, which will serve as a forum for discussing interdisciplinary research in progress and highlighting visiting speakers.
- *Annual Symposium:* At the end of each spring semester, all SAGE IGERT fellows and faculty will convene for a symposium featuring keynote speakers, student poster presentations, and topical sessions.
- *Outreach:* All fellows must participate in at least one outreach activity during each of their first two years of the program.
- *Professional Development:* Trainees will participate in professional development activities that are held in conjunction with the seminar series.

Student Eligibility

- ❑ Enrolled* in a PhD program in the College of Chemistry, College of Natural Resources (including Energy & Resources Group), Haas School of Business, School of Public Health, Goldman School of Public Policy, or College of Engineering,

&

- ❑ Have at least 2 years remaining in your graduate program. (Preference will be given to students in their first 3 years of graduate school)

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- ❑ Are a US citizen or permanent resident (NSF requirement).

* We encourage concurrent applications for incoming students.

Application Materials- Due Nov. 5th

1. Academic Transcripts
2. Resume including employment and publication detail (if any)
3. A Research Statement (2-3 pages) explaining how your research interest would advance the goals of the SAGE program, and how they would benefit from interdisciplinary collaboration and study. Include information about how you might take advantage of campus resources (e.g. Centers, labs, programs, etc.) that could contribute to your proposed research project.
4. Two Letters of support—one from your home department advisor and the other from a faculty in another department or school who would be willing to help advise an interdisciplinary project. These letters should address your proposed project as well as your academic qualifications.
5. Letter of Reference from a previous academic advisor (or professional employer, e.g., government agency, company) outside of the SAGE program.
6. Statement of your existing funding support. Please let us know how you are currently funded including any external fellowships and/or department support in addition to GSI and GSR appointments.

http://sage-bcgc.berkeley.edu/traineeship/apply

SAGE Faculty Presentations

Name	Department	Email
Severin Borenstein	Business	borenste@haas.berkeley.edu
Chris Rosen	Business	crosen@haas.berkeley.edu
Dan Farber	Law	dfarber@law.berkeley.edu
Alastair Iles	ESPM	alastair.iles@gmail.com
Michael O'Hare	Public Policy	ohare@berkeley.edu
Joe Guth	Public Health	jguth@berkeley.edu
Meg Schwarzman	Public Health	mschwarzman@berkeley.edu
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John Arnold	Chemistry	arnold@berkeley.edu
John Hartwig	Chemistry	jhartwig@berkeley.edu
Don Tilley	Chemistry	tdtilley@berkeley.edu
Peidong Yang	Chemistry	p_yang@berkeley.edu
Richmond Sarpong	Chemistry	rsarpong@berkeley.edu
Michelle Chang	Chemistry	mcchang@berkeley.edu
Chis Vulpe	Toxicology	vulpe@berkeley.edu
Martyn Smith	Public Health	martynts@berkeley.edu
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Luoping Zhang	Public Health	luoping@berkeley.edu
Edmond Seto	Public Health	seto@berkeley.edu
Kirk Smith	Public Health	krksmith@berkeley.edu
Michael Jarrett	Public Health	jerrett@berkeley.edu
Tom McKone	Public Health	temckone@lbl.gov
David Dornfeld	Mechanical Engineering	dornfeld@berkeley.edu

Severin Borenstein, Haas School of Business

E.T. Grether Professor of Business and Public Policy, Haas School of Business
Co-Director, Energy Institute at Haas
Director, University of California Energy Institute

- Research
  - Economics of renewable energy
  - Electricity regulation and tariff design
  - Market mechanisms for addressing climate change
  - World energy markets
- Teaching
  - "Energy and Environmental Markets" (masters course)
  - "Economic Analysis for Business Decision Making" (masters course)
- Professional Activities
  - Advising California on implementation of cap and trade market and other GHG mitigation programs
  - Advised DOE and CA on smart grid implementation
- For More Information
  - http://faculty.haas.berkeley.edu/borenste/

Chris Rosen, Haas School of Business

My Research

- **Concerns the history of America's early struggles with industrial air and water pollution**
- **Change in American**
  - Pollution beliefs
  - Regulatory policies
  - Legal doctrines
  - Technologies for reducing pollution emissions
- **Leadership of regulatory movements**

How it relates to SAGE

- It provides perspective and insight into the cultural, legal, regulatory, and technical dimensions of systems change
- And into the challenges of movement building, including the importance of collaborative approaches
- Contact: crosen@haas.berkeley.edu

Dan Farber: Law Climate and Energy

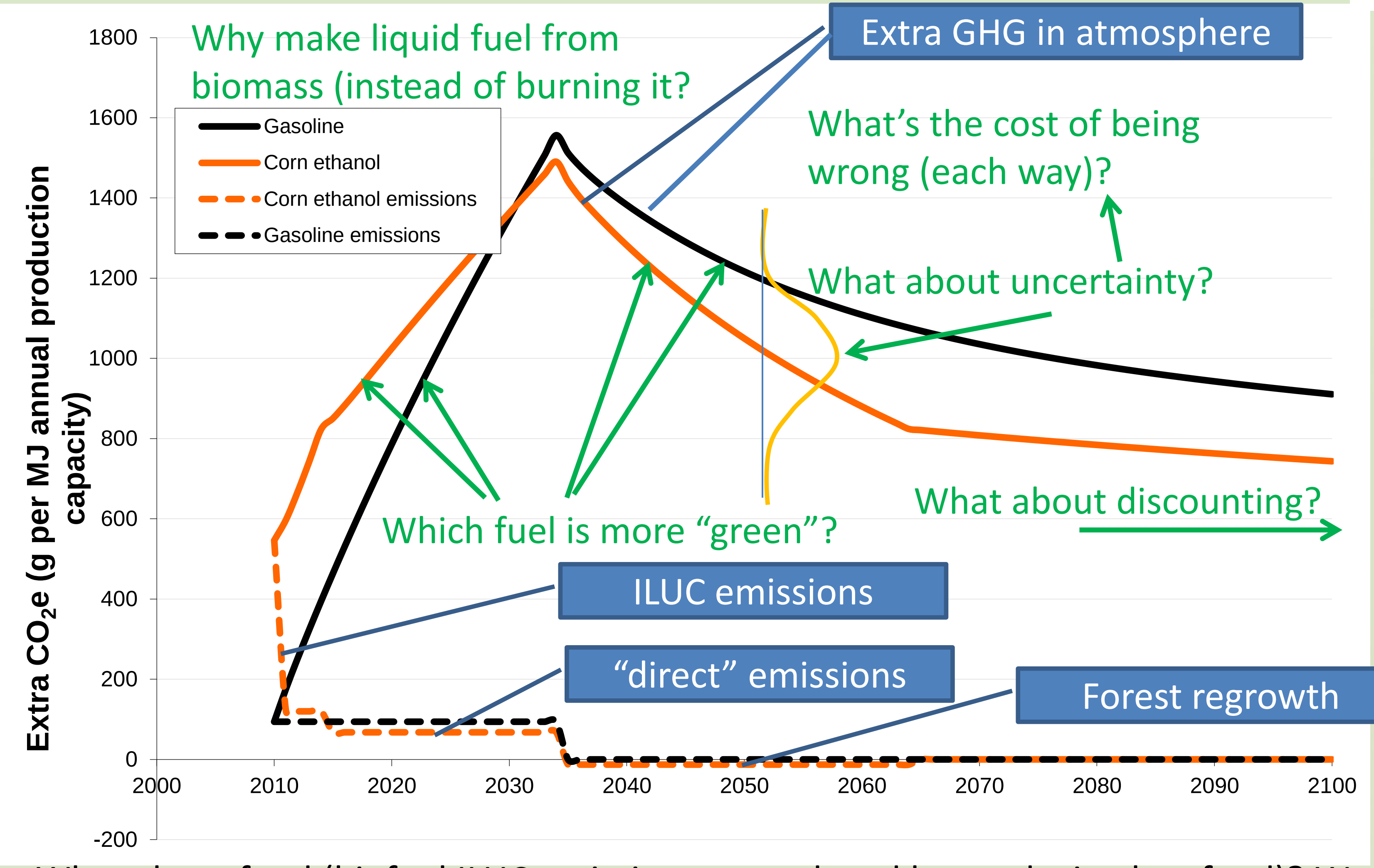
- **Climate law and the energy system:** How EPA regulations and state carbon laws function and impact energy production and use.
- T**ransnational issues in energy law**: How WTO rules, local regulations, and transboundary cooperation shape conventional and renewable energy production.
- **Energy regulation and uncertainty:** How the legal system responds to uncertainties in future energy and climate trajectories.

Alastair Iles, Environmental Science, Policy & Management

- Green chemistry policies and regulation
  - Biobased chemicals
  - Evaluation of materials
- Environmental health politics (biomonitoring and environmental justice)
- Sustainable farming systems (agroecology)
- Development of a systems approach that integrates GC principles, public policies, processes for evaluating materials, environmental health, and upstream inputs (e.g., agriculture) into technology design
- Application of this approach to biofuels, batteries, and PV systems

Michael O'Hare, Goldman School of Public Policy
(ohare@berkeley.edu)

Corn ethanol: 25 yrs production, 60g direct emissions, 776 g LUC, 30 yrs recovery of 50% of LUC http://rael.berkeley.edu/BTIME



What about food (biofuel ILUC emissions are reduced by producing less food)? Water?

Michael Wilson, Meg Schwarzman, Joe Guth, Akos Kokai
Center for Occupational and Environmental Health

Our research

- **Research into green chemistry and toxicity testing approaches**
  - PLUM – Public Library of Materials (online database of chemical hazard information designed to facilitate alternatives assessment)
  - Breast Cancer & Chemicals Testing project
  - Alternatives Assessment methodologies
- **Engagement**
  - Researchers are members of three California EPA advisory boards relating to green chemistry, and provide comments on proposed GCI regulations and testimony to the California legislature.
- **Labor Education and Training**
  - Researchers are working with the United Steelworkers and the Blue Green Alliance to identify safer alternatives and to advance green chemistry and green jobs

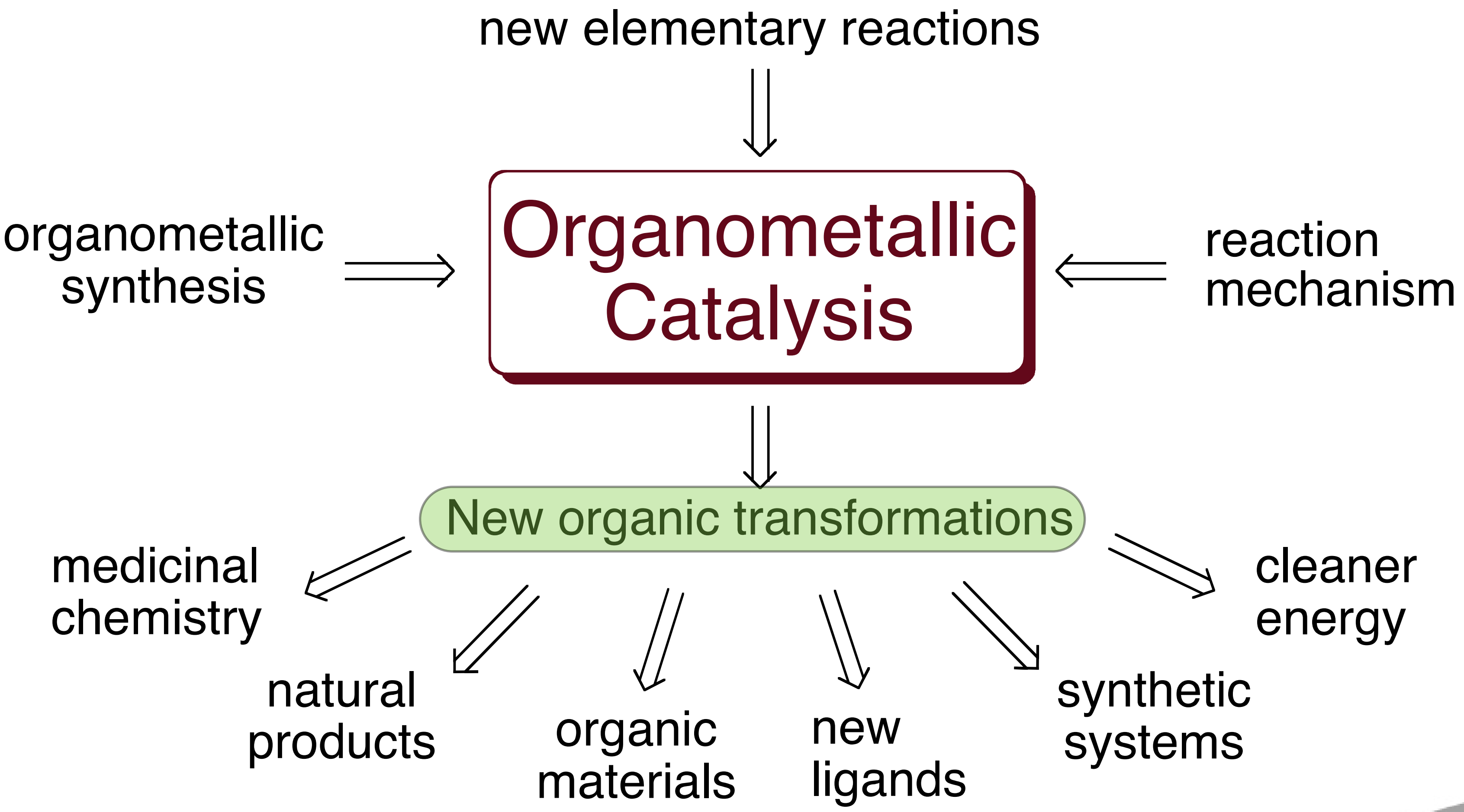
John Arnold, Chemistry

Synthetic Chemistry

- Catalysis
  - Alternatives to Pt in fuel cell catalysis
  - Non-precious metal replacements for existing catalytic processes
- Alternatives to Fossil Fuels
  - Fundamental chemistry of *f*-element compounds

- Catalysis - a bed-rock principle of Green Chemistry
- Sustainable materials
- Efforts to tie in with toxicity research, training

Hartwig Group: Mechanism-Driven Discovery of Catalytic Reactions



Don Tilley, Department of Chemistry

Catalysis in Solar Energy Conversion

- Synthesis and study of catalysts for water oxidation:

-inorganic nanostructures

-molecular precursors to inorganic nanostructures, surface sites

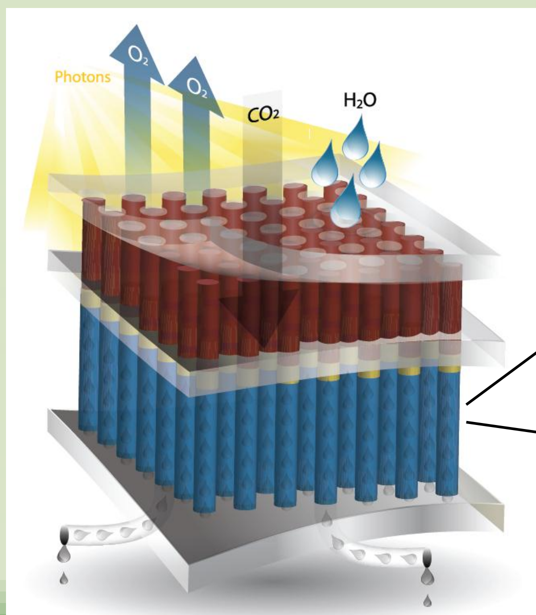
-molecular models for mechanistic studies

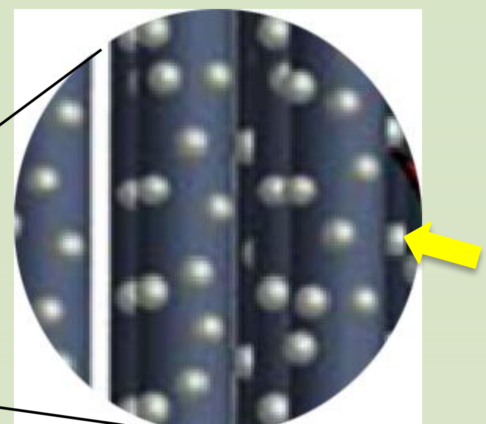
- Renewable energy that is:

-abundant

-clean

-affordable

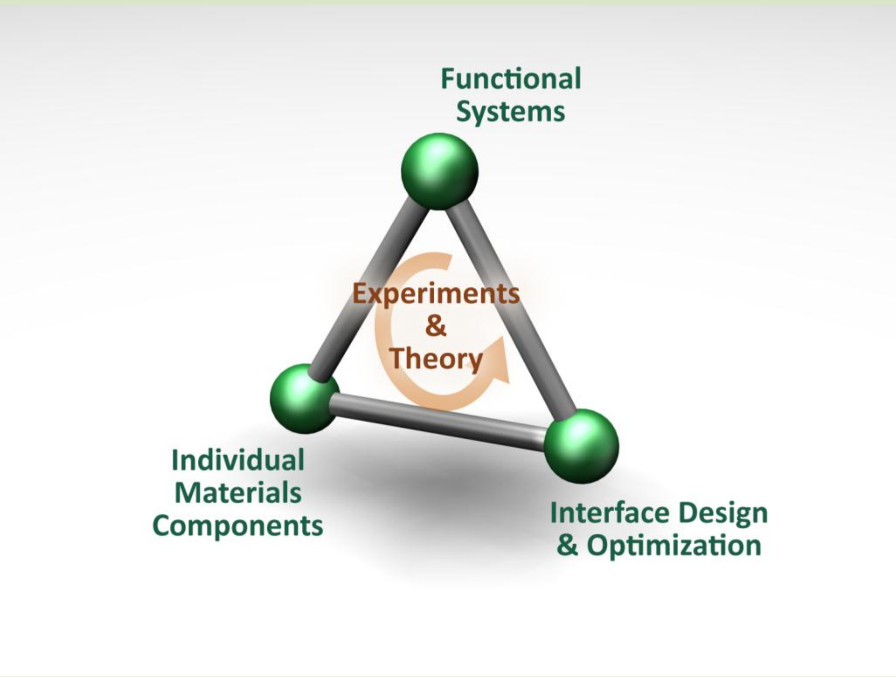


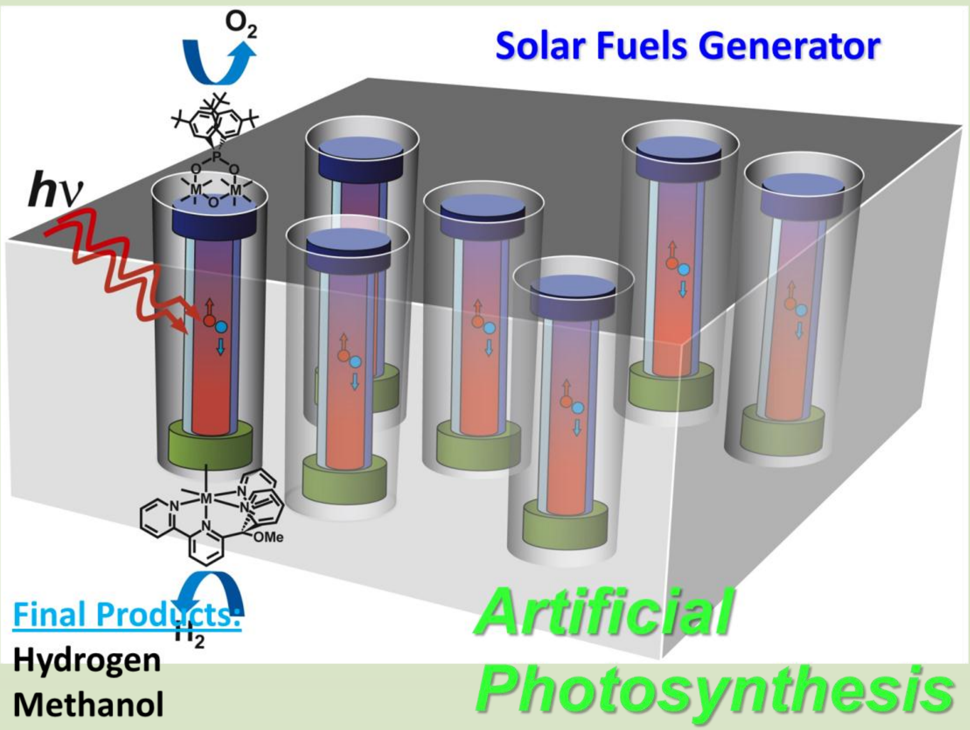


earth-abundant, low-overpotential, high TOF catalysts

Peidong Yang, Chemistry

Towards systems materials engineering





P. Yang, J. Tarascon, *Nature Mater.*, 11, 560, 2012.

Richmond Sarpong, Dept. Of Chemistry

Green Routes for Synthesis

- *Synthetic Route Assessment*
  Has the most efficient strategy for synthesis been identified?
- *Green Assessment*
  How can the principles of green chemistry be applied to identify a better synthetic route
- *Integrative Approach*
  Partner with toxicology, public health and policy to engage in a systems approach for synthesis

- *Relevance to SAGE*
  These exercises may identify novel processes for synthesis that are more efficient and cost effective:
  - Pharmaceutical partners may be more interested in these "vetted" approaches.
  - The chemistry, toxicology and finances of synthesis will be considered at one time

Contact: rsarpong@berkeley.edu

Michelle Chang, Chemistry

Chemical synthesis using living cells

- Our laboratory works in synthetic biology and metabolic engineering. We build new synthetic pathways to make fuels, pharmaceuticals, and materials using living cells as a one-pot aqueous chemical reactor.
- We are developing new methods to synthesize small molecule targets from renewable materials by microbial fermentation. This approach increases synthetic efficiency while reducing the use of organic reagents.

Chris Vulpe, Nutritional Sciences and Toxicology

Conserved cellular response to chemicals

Functional Toxicology
Predict chemical reactivity in organisms

High throughput toxicity assays
Enable rapid screens of chemicals

Genetic diversity in toxicant response
Consider variability in chemical effects

Eco-indicator genomics
Screen chemicals for effects to environmentally relevant organisms

Genes & Environment Laboratory, Public Health

Martyn Smith, Stephen Rappaport, Luoping Zhang

- **Toxicology and molecular epidemiology**
- **Benzene, Formaldehyde, Arsenic, TCE**
- **Superfund Research Program**
- **Causes of leukemia and lymphoma**
- **The Exposome**
- ***In vitro* toxicology in human cells**

School of Public Health
211 Hildebrand Hall

Martyn is Director of Berkeley Institute of the Environment

martynts@berkeley.edu
http://gel.berkeley.edu
http://superfund.berkeley.edu

Edmund Seto, School of Public Health

Health Impact Assessment

- *Health Impact Assessment*
  What are the potential health impacts of new energy innovations and policies?
- *Exposure Assessment*
  Are these positive or negative health impacts, and for whom?
- *Equity Assessment*
  Are the health impacts distributed equitably among populations of color and income?

- *Relevance to SAGE*
  These assessments may lead to more systematic and process-driven analyses of new green innovations and policies, including:
  - Earlier consideration of health in the development and policy lifecycle.
  - Consideration of short and long term exposures and toxicity of new chemicals
  - Avoidance of later environmental and social injustices.

Contact: seto@berkeley.edu

Prof. Kirk R. Smith, School of Public Health

Household Energy, Climate, and Health

- The largest and oldest research group in the world conducting field studies and global assessments of the health and climate implications of household fuel use in developing countries. Focuses on independent interdisciplinary studies of current conditions and modern alternatives.
- 3+ billion people rely on household biomass, coal, kerosene, and charcoal, which are poorly burned in traditional settings with major negative health and environmental impacts. Finding clean long-term solutions is critical for developing sustainable green energy globally.

Michael Jerrett, School of Public Health

Professor and Chair, Division of Environmental Health Sciences
School of Public Health

Spatial Analysis for Public and Environmental Health

Topical Areas

- Exposure assessment for and health effects assessment of air pollution
- Built environment impacts on physical activity, environmental exposures, and particularly active transportation
- Novel participatory and ubiquitous sensing technologies for exposure assessment (e.g. cell phones)

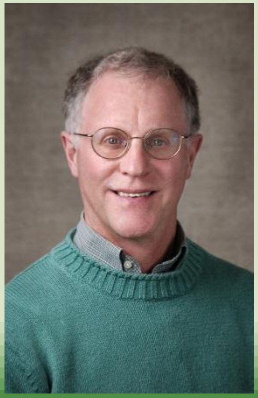
Related to Green Energy

- Air pollution expected to be influenced by fuel mixtures
- No comprehensive health impact assessment frameworks have been developed for biofuels
- Ubiquitous sensors could be used to monitor impacts of biofuels on air quality
- Interested also in whether “green energy” includes active transportation – seems it should – but not sure if it’s in scope of this grant

Tom McKone, School of Public Health,
Lawrence Berkeley National Laboratory

Sustainable Energy Systems Research

- Energy and health
- Emerging energy technologies total cost (price and externalities)
- Life-cycle impact assessment for biofuels
  - carbon footprint
  - health burden
  - water footprint



- Framing energy-health research questions
- Quantifying and valuing life-cycle impacts for all SAGE technologies
- Can provide support broadly for biofuels projects

Photo is from WW Nazaroff

David Dornfeld, Mechanical Engineering

Research in the **Laboratory for Manufacturing and Sustainability** is concerned with the analysis and improvement of manufacturing processes, systems and enterprises and the development of tools to analyze their sustainability.

LMAS Research

- Green supply chains
- Metrics and tools for assessing environmental and social sustainability
- Modeling sustainable manufacturing processes and systems
- Energy and environmental impacts of materials

Connection to SAGE

LMAS conducts impact assessments of technologies and systems in early stages of development. LMAS work is crucial to multiple SAGE research thrusts and:

- Enables ***Integrated Impact Assessment of Materials*** by incorporating the language and expertise of multiple disciplines, including engineering, chemistry, health, and finance
- Evaluates ***Environmental Systems Impacts*** throughout the life cycles of green energy systems
- Develops ***Health Impact Metrics*** that connect engineering decisions to the health of workers, communities, and the global population

For more information visit http://lma.berkeley.edu/ and Prof. Dornfeld's blog http://green-manufacturing.blogspot.com/

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Thank You

Questions?