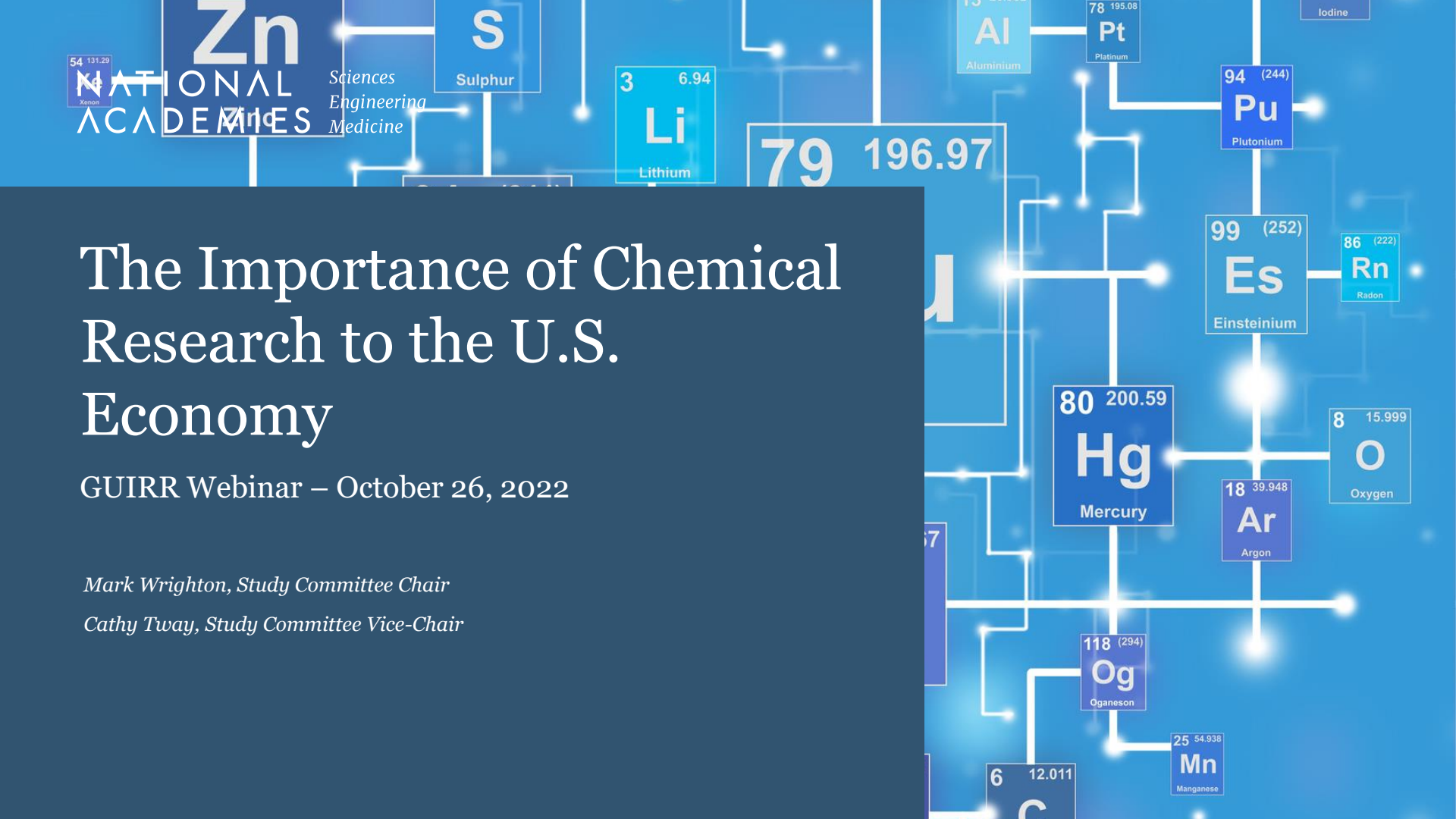

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The Importance of Chemical Research to the U.S. Economy

GUIRR Webinar – October 26, 2022

Mark Wrighton, Study Committee Chair

Cathy Tway, Study Committee Vice-Chair

Report Information

Study Committee:

- **MARK S. WRIGHTON**, Chair, George Washington University
- **CATHY L. TWAY**, Vice Chair, Johnson Matthey
- **ASHISH ARORA**, Duke University
- **RAYCHELLE BURKS**, American University
- **JOSEPH M. DESIMONE**, Stanford University
- **SHANTI GAMPER-RABINDRAN**, University of Pittsburgh
- **JEANETTE M. GARCIA**, IBM
- **JAVIER GUZMAN**, ExxonMobil
- **MARTHA HEAD**, Amgen
- **RUSSELL MOY**, Southeastern University Research Association (through January 2022)
- **KRISTALA L. J. PRATHER**, Massachusetts Institute of Technology
- **JASON SELLO**, University of California, San Francisco
- **BALA SUBRAMANIAM**, University of Kansas
- **JEAN W. TOM**, Bristol Myers Squibb

Sponsors:

- National Science Foundation – Division of Chemistry
- Department of Energy – Office of Science
- Department of Energy – Fossil Energy and Carbon Management
- National Institute of Standards and Technology
- American Chemical Society

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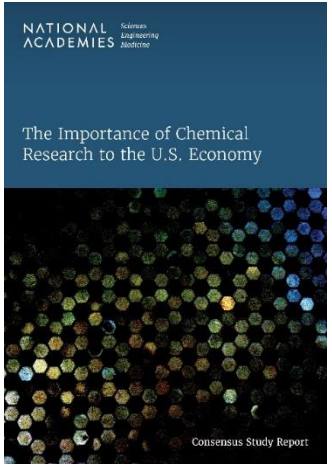


Committee's Charge

Statement of Task:

- The committee will:
  - Examine and define the role of the chemical industry in the U.S. economy.
  - Assess investments in long-term fundamental research
  - Explore strategies for targeted research investments in the chemical sciences by both the public and private sectors to stimulate economic growth while also advancing environmentally sustainable practices and/or integrating a diverse chemical economy workforce.

This Report is Very Timely

"Because our industrial strategy centers on technology, **we want to invest in research**, development, advanced manufacturing. Sixty years ago, our government spent more than twice as much on research as a percentage of our economy as we do now – investments that, in turn, catalyzed private-sector innovation. It's how we won the space race, invented the semiconductor, built the internet. **We used to rank first in the world in R&D as a proportion of our GDP – now we're ninth.**"

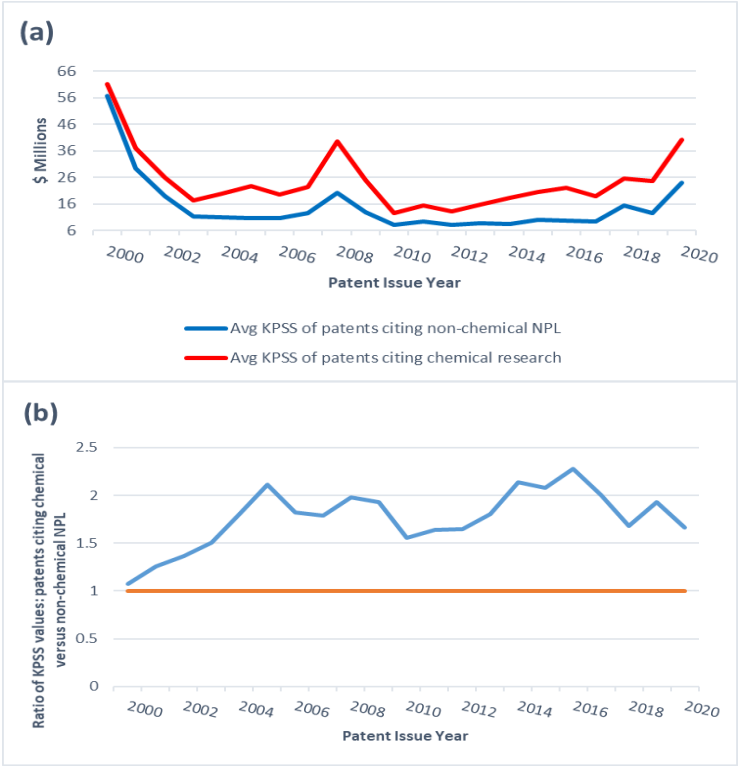
-Secretary Antony J. Blinken, Speech at The George Washington University, Washington, DC, on May 26, 2022

Central Themes of the Chemical Economy Report

1. **Balancing U.S. competitiveness and collaboration in the global chemical economy**
2. **A changing landscape within the chemical enterprise**
3. **Emerging processes and technologies**
4. **A focus on sustainability**

Understanding the Economic Impacts of Chemistry

- When considering industries that are dependent on chemistry, the chemical enterprise was responsible for approximately **$5.2 trillion of U.S. GDP in 2020, approximately 25% of GDP**.
- Patents that cite chemical research, are on average more valuable than patents that cite other non-chemistry research
- **Chemical patents accounted for 14% of all corporate patents between 2000 and 2020, but they accounted for 23% of all value in the same time period**
- It is challenging to directly link chemical research to economic impact because each chemical product or process relies on a broad body of chemical knowledge and discovery that is built over decades or centuries



ACC, 2021; Fleming and Basco, 2021

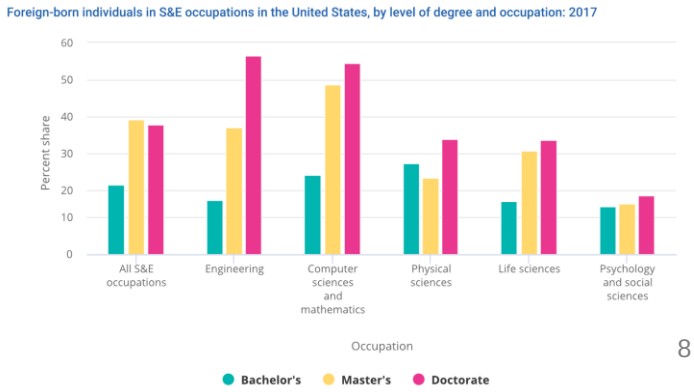
Economic Analyses to Better Understand how Chemical Research Impacts the Economy

- **Recommendation:** To help guide policy and funding decisions around chemical research, federal agencies who fund and track data related to scientific research should collaborate to collect, and make available, the tools and data needed to understand the impact of fundamental chemical research on the chemical economy. As a part of this initiative, large-scale evidence-building efforts to collect, standardize, use, and interpret these data, should be funded.

Global Competitiveness and the Chemical Economy

- The U.S. chemical economy is part of a complex ecosystem that, while competitive with chemical industries in other countries, is also heavily reliant on them for collaboration, innovation, and workforce needs

- The chemical economy is critically important for our national economy and our leadership in the international chemical enterprise. Our nation's leadership in the chemical industry cannot be taken for granted, and this leadership needs continued and sustained nurturing and support.



NATIONAL ACADEMIES Sciences Engineering Medicine

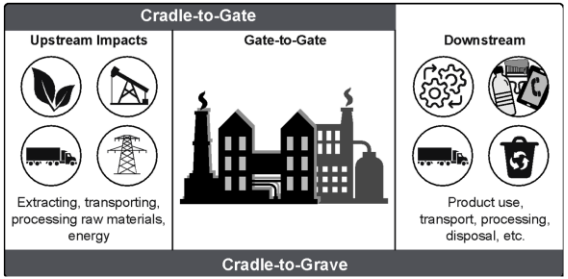
NSB, 2019

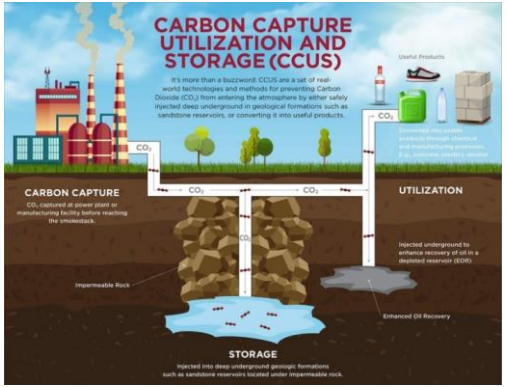
Recommendations for Strengthening the U.S. Economy and U.S. Competitiveness

- **Recommendation 1:** To foster fundamental chemical research and maintain U.S. competitiveness in the chemical economy, the U.S. chemical enterprise should support funding, workforce, and policy structures that attract international researchers and create a nurturing environment for all research talent.
  - Fund a large breadth of chemical research
  - Fund chemical research with a focus on environmental sustainability
  - Support the open exchange of ideas in the chemical sciences

Sustainability for the Chemical Economy

- The chemical economy is directly and/or indirectly responsible for considerable negative impacts on the environment. Ironically, chemical research will be critical to solving many of these issues and help the world move toward achieving the United Nations Sustainable Development Goals
- Areas that are prime for future chemical innovation:
  - better measurements for life-cycle assessments;
  - enhancement of recycling technologies and co-design of plastic products for recyclability;
  - sustainable syntheses;
  - sustainable feedstocks and energy sources;
  - carbon capture, utilization, and storage;
  - monitoring and improving air quality, water safety, and food safety;





Subramaniam, 2021b; Mah, 2021

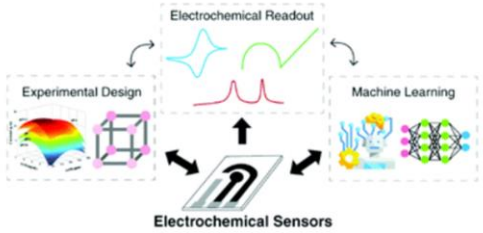
Challenging the Underlying Assumptions of Chemical Research

- **Conclusion:** As the world moves deeper into its current energy transition, an increasing focus on circularity and new technologies will significantly alter the operations and processes of current industries, creating new opportunities and challenges that will benefit from fundamental chemistry and chemical engineering advances.

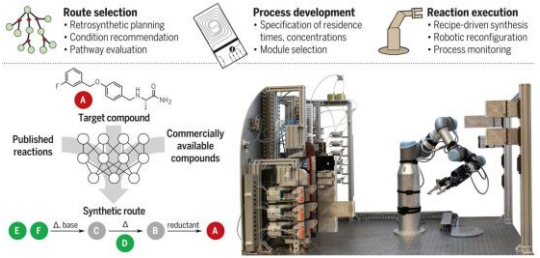
- **Recommendation:** Changes in energy sources complemented by the technology and processes offered by chemical companies will lead to entire industries being created, transformed, and terminated. A group of experts from chemistry and other impacted disciplines, who represent the chemical economy and academic research, should be convened to assess the implications of these industrial shifts and understand their impacts on current chemical research paradigms.

Emerging and Transitioning Areas of the Chemical Sciences

Measurement

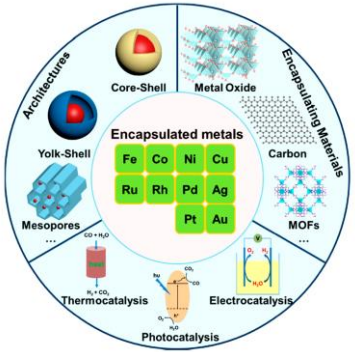


Automation



Computation

Catalysis

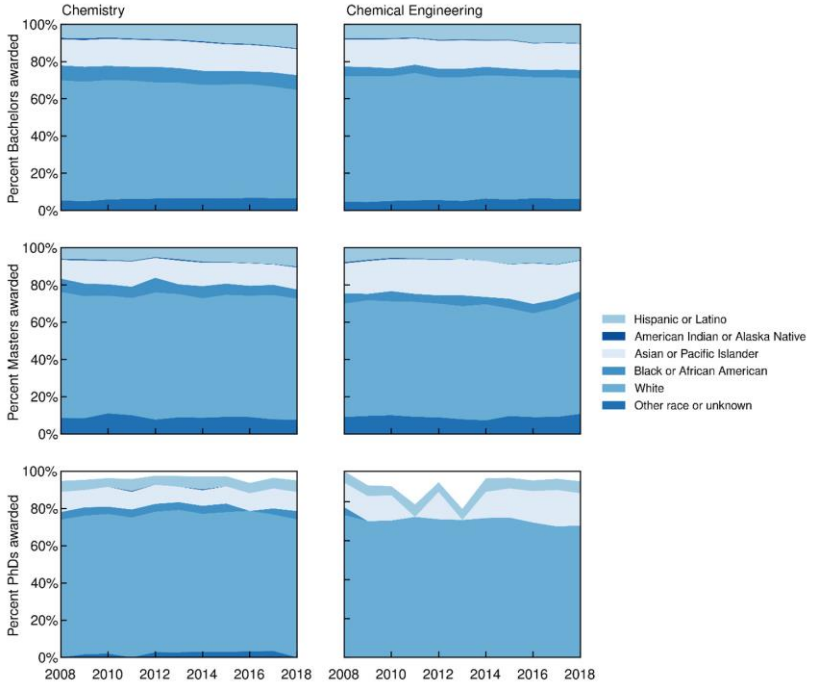


Data is an indispensable tool for the chemical sciences research community, and will help to increase the pace and efficiency of innovation

Puthongkham et al., 2021; Coley et al., 2019; https://www.flickr.com/photos/ibm_research_zurich/51098680334/; Gao et al., 2020

The Future Chemical Workforce – Diversity, Equity, and Inclusion

- **Conclusion:** A skilled science and engineering workforce paired with a diverse, inclusive, and equitable science and engineering research enterprise is central to a thriving, nimble chemical economy equipped to respond to emerging challenges and maintain U.S. competitiveness.
- The key needs to advance a diverse workforce with equitable opportunities are:
  - Continuous and high quality mentorship
  - Improved professional development at all levels
  - An inclusive and innovative chemistry learning environment



Source: https://ncsesdata.nsf.gov/sere/2018/.

Funding Chemical Research

- Major funding conclusions and recommendations from the committee center around the following ideas:
  - Funding opportunities should cover a broad range of topics
  - SBIR and STTR programs foster an important avenue where fundamental research has the opportunity to bring new products or processes to market
  - Foundation and individual philanthropic support is likely to grow as a resource for innovations in chemistry
  - Investment in the infrastructure at research universities is needed so trainees have access to the newest technologies being used in the chemical workforce.