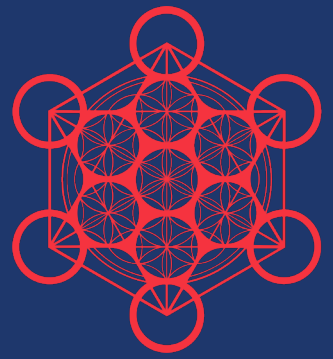
Competitiveness in Basic Energy Science



THE
KAVLI
FOUNDATION

Basic Energy Sciences Advisory Committee (BESAC) Subcommittee

Panel on International Benchmarking
November 2023

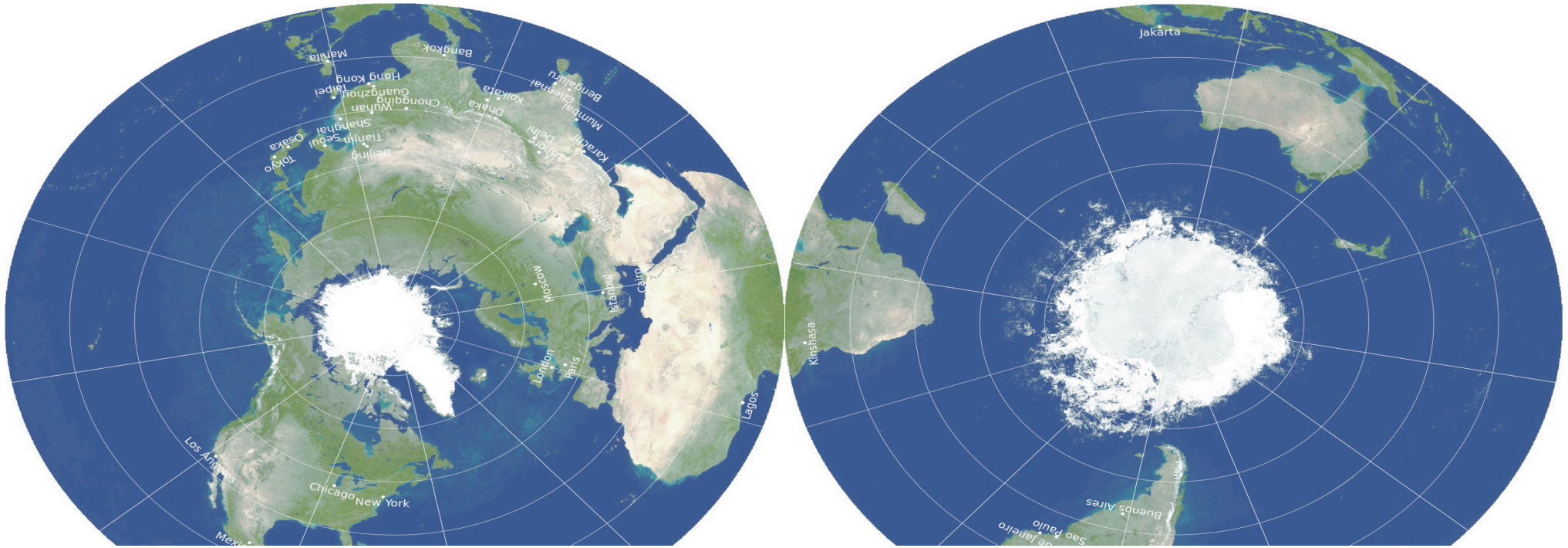
Cynthia Friend, Chair of BESAC
Kavli Foundation President
T.W. Richards Professor of Chemistry
Emerita, Harvard University

CAN THE U.S. COMPETE *in Basic Energy Science?*

Critical research frontiers and strategies

A report by the Basic Energy Sciences Advisory Committee (BESAC) Subcommittee

BESAC was the first DOE advisory committee to examine international competitiveness; methodology shared with other committees



https://science.osti.gov/-/media/bes/besac/pdf/Reports/AH_DOE2021-International_Benchmarking.pdf?la=en&hash=ED170283EB287B5B60F497B1DC87CBBADDAF1841

Where does the U.S. stand now?

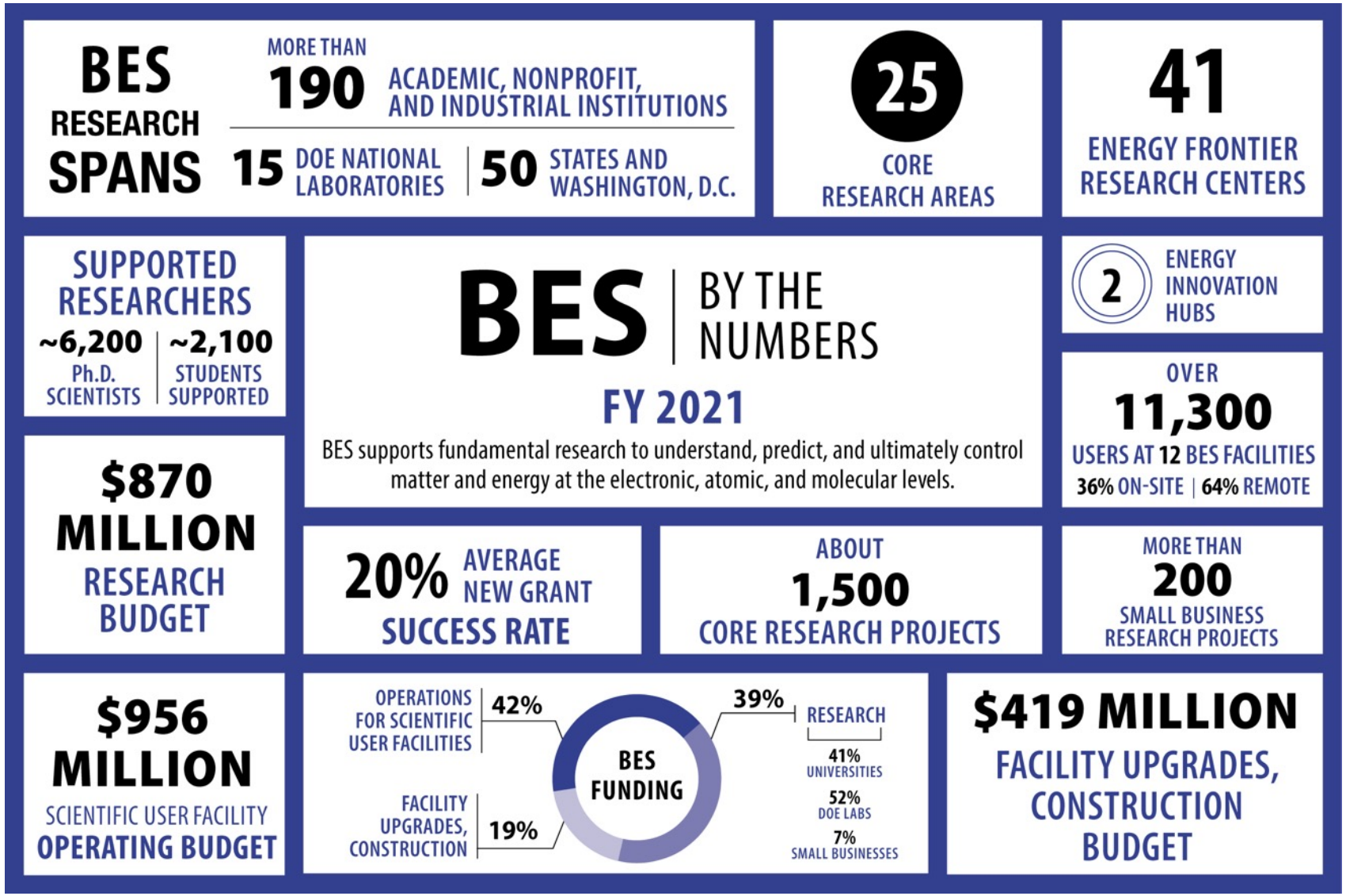
U.S. DEPARTMENT OF ENERGY | Office of Science

Summary of Charge

1. Identify key areas of its mission-relevant research and facility capabilities in which U.S. leadership is most threatened.
2. Advise on modifications to existing trade-offs or new ways to leverage scarce resources.
3. Identify incentives that will retain and attract scientific talent.

BESAC Subcommittee: team of subject-area experts and experienced administrators with international experience.

Overview of Basic Energy Sciences Activities



Methodology overview (Team 1: Areas)

Select Areas	Rank and Select Deep-Dives	Analyze Deep-Dives	Previous Reports and Community Input
Used Basic Research Needs reports and expertise of team to select strategic areas of importance to BES	Discussions with experts and leaders of Basic Research Needs reports	Publication metrics (ORISE+committee) Conference analysis (committee)	Awards, other metrics and community input
Scientific Areas 1, 2, 3, 4, 5	Expert ranking results	Quantitative ranking results	Webinars promoted by ACS, MRS, APS, ECS

Critical Areas for Basic Energy Research

Five broad areas identified as fundamental scientific topics for U.S. leadership

Area	Examples
Quantum Information Science	Quantum computation, quantum communication, quantum simulation, quantum sensing
Science for Energy Applications	Membranes, interfaces, energy storage, sustainable fuels
Matter for Energy and Information	Quantum materials, mesoscience, nanoscience, neuromorphic computing
Industrially-Relevant Science for Sustainability	Chemical upcycling of polymers, electrocatalysis, carbon capture, transformative manufacturing
Advanced Research Facilities	Neutron facilities, synchrotron and free electron X-ray sources, electron microscopy

Likely that trends apply to other fields of interest in energy science

Methodology (Team 2)

WHAT WAS DONE:

Conducted over 50 consultations using a request-for-information

Extracted hypotheses for key strategic themes

Input from science community at townhalls (APS, ACS, MRS, ECS)

Follow up with additional consultations

WHO WAS CONSULTED:

U.S. lab leadership

NSF leadership

Private foundation leadership

University leadership

International leadership in research, facilities and management

Early-career scientists (e.g., DOE Early-Career Awardees)

U.S. and international industry leadership

Can the U.S. compete in Basic Energy Sciences?

Yes, but action is needed

Key Findings

- Other nations overtaking U.S.
- Tough competition for global talent
- Facilities are no longer unique
- Support for small/mid-scale instrumentation diminished

Strategies

- Increase investment in basic scientific research
- Boost support for scientists; enhance U.S. competitiveness for talent
- Balance need for new facilities with support for existing facilities
- Better integrate research from basic to applied to industrial

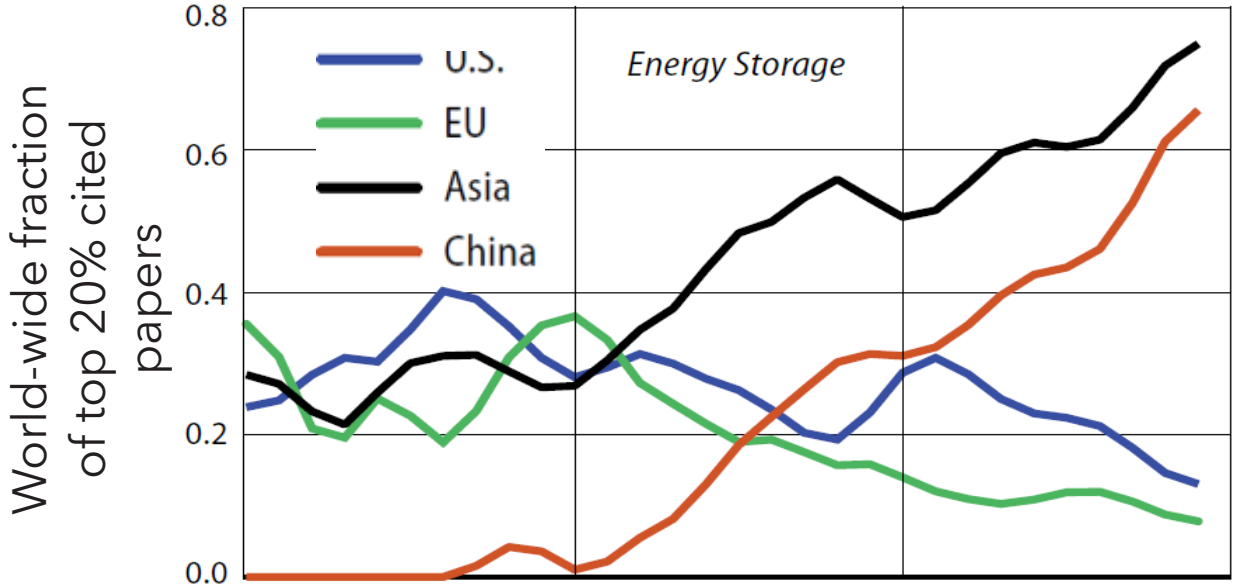
Potential role of scientific societies to get the word out about strategies

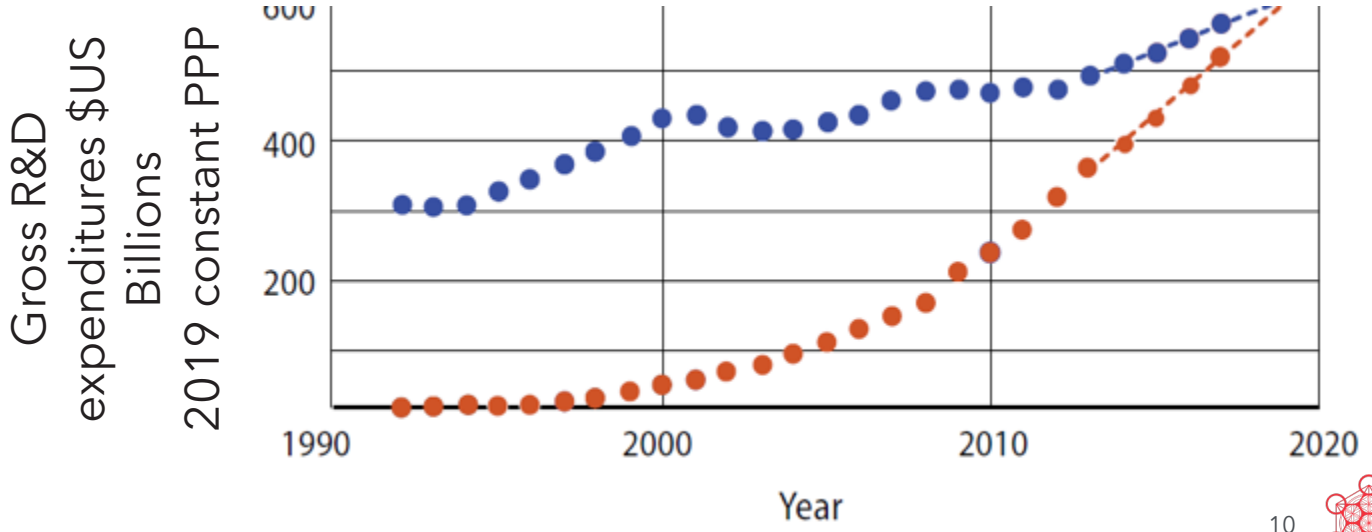
Finding: Other nations are catching up, overtaking U.S.

Overall downward trend in competitiveness in all research areas, 2010-present

Increased investment by E.U. and China; nearly flat U.S. funding

Similar trends found in other areas—see report





Expenditures data from *The Perils of Complacency, America at a Tipping Point in Science and Engineering* (American Academy of Arts and Sciences, 2020), www.amacad.org/publication/perils-of-complacency

Finding: Global talent recruitment and retention is critical

U.S. is no longer automatic winner in global competition

Other countries offer more sustained support for careers; e.g., ERC grants

Wider access to advanced research facilities in other countries, with strong staff support

Matt Chase

Strategies: Boost support for scientists at all career stages

Undergraduate support: need to attract students from non-traditional backgrounds (not in report)

Graduate funding: challenges in recruiting, supporting international students

Early-career stage: other regions/countries have larger, generous programs (e.g., DOE vs ERC)

Mid-career level: virtually no opportunities for U.S. physical and engineering scientists to obtain single investigator funding for more than three years at a time (e.g., DOE vs ERC)

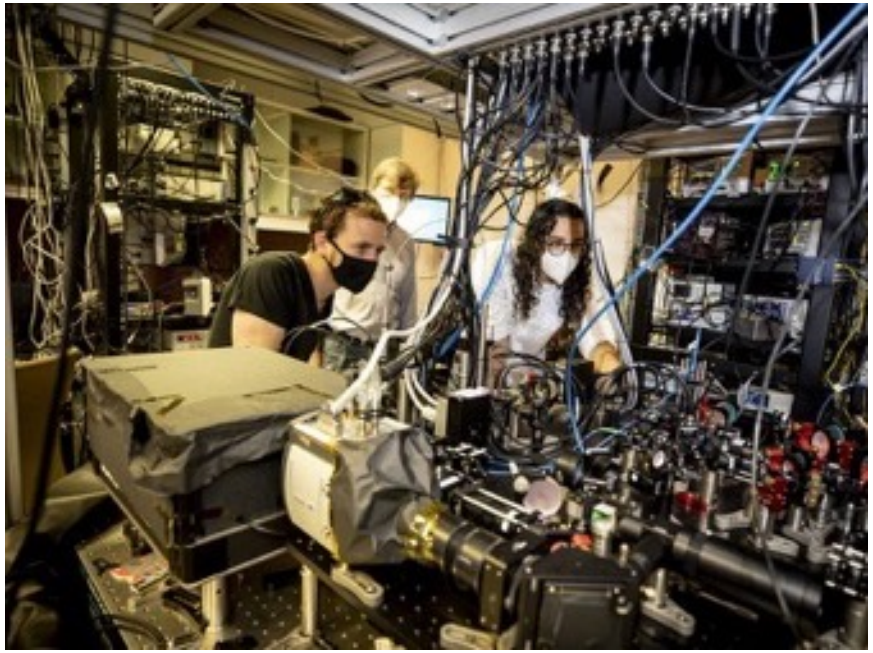
Strategies: Support facilities; computation and analysis

Advanced, large-scale research facilities are critical to leadership

7 Nobel Prizes over a 25-year period were enabled by synchrotron X-rays (NSLS-II pictured).

Photo credit: Brookhaven national laboratory

Computation, data analysis methods, computer hardware and architecture critical for all research areas



256-bit "programmable quantum simulator" computer in the Lukin lab (Harvard), with Dolev Bluvstein, Mikhail Lukin, and Sepehr Ebad.

Photo: Rose Lincoln/Harvard Staff Photographer

BESAC follow up: Charge to Develop Strategies for Research Investments, 2023

Advice requested on BES investment strategies for effective use of available resources

- Builds on Benchmarking Report "strategies for success" plus recent national focus on the strategic implications on government investment in science, including the CHIPS and Science Act (August 2022).

- Rising costs for research, facility operations, and facility construction require ongoing prioritization of research topics.

- Request for proposed area-agnostic strategies that BES can apply to specific research topics as BES and the research community move forward, including topical priorities, investment balance, modality balance, discovery and use-driven balance, international, frequency of strategy evaluation.

CAN THE U.S. COMPETE *in Basic Energy Science?*

Critical research frontiers and strategies

A report by the Basic Energy Sciences Advisory Committee (BESAC) Subcommittee

FINDINGS

Overall downward trend in competitiveness in all research areas

STRATEGIES

Need for *strategic* increases in research and facilities support and new approaches to attracting and retaining talent

International Benchmarking BESAC Subcommittee

Team of subject-area experts and experienced administrators with international experience.

Subcommittee Leads	
Chair **Cynthia Friend**	Harvard University
Vice Chair **Matt Tirrell**	University of Chicago
Team Lead **Eric Isaacs**	Carnegie Institution for Science
Team Lead **Zhi-Xun Shen**	Stanford University

BES Participants	
Linda Horton	Basic Energy Sciences
Thomas Russell	Basic Energy Sciences

Participants	
Al Hammond	Editor/writer
Jeffrey Miller	Logistics/Data/Analysis

Subcommittee Members	
Frank Bates	University of Minnesota
Anthony Cheetham	UC Santa Barbara
Serena DeBeer	Max Planck Institute for Chemical Energy Conversion
Yan Gao	GE (Retired)
Brett Helms	LBNL
Marc Kastner	MIT (Retired)
Maki Kawai	Institute for Molecular Science
Y. Shirley Meng	University of California, San Diego
Pietro Musumeci	UCLA
Jüergen Mlynek	Humboldt University Berlin
Monica Olvera de la Cruz	Northwestern University
Abbas Ourmazd	University of Wisconsin – Milwaukee
Maria Santore	University of Massachusetts – Amherst
Eric Stach	University of Pennsylvania
Esther Takeuchi	Stony Brook
Birgitta Whaley	UC Berkeley

International Benchmarking Support

Logistics and Technical Support	
Katie Runkles	Basic Energy Sciences
Jeffrey Miller	Harvard University
Leah DeFrancesco	Harvard University
Tammy Click	ORISE
Al Hammond	Editor/writer
Maggie Powell	Publication design

Library Science Support
Tiffani R. Conner
Ann B. Gonzalez
Holly Holt
Jim Malone
Nathan Murray
Jennifer Tucker

Graphics Support
Mike Dunner
David M. Goldberg
J. Richard Gott III
John Hill
Eric Johnson
Jeffrey Miller
Lisa Miller
Dennis Mills
Piero Panetta
Robert Schoenlein
Robert J. Vanderbei