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About Science and Engineering Indicators

Science and Engineering Indicators (Indicators) is a congressionally mandated report that provides high-quality quantitative information on the U.S. and international science and engineering enterprise. *Indicators* is factual and policy neutral. It does not offer policy options, and it does not make policy recommendations. The report employs a variety of presentation styles—such as narrative text, data tables and figures—to make the data accessible to readers with different information needs and different information-processing preferences.

The data are "indicators," that is, quantitative summary information on the scope, quality, and vitality of the science and engineering (S&E) enterprise or its change over time. The indicators in this report are intended to contribute to an understanding of the current environment and to inform the development of future policies. The report does not model the dynamics of the S&E enterprise. It is used by readers for a variety of purposes, and they have different views about which indicators are the most significant for different purposes.

Indicators is prepared under the guidance of the National Science Board by the National Center for Science and Engineering Statistics (NCSES), a federal statistical agency within the National Science Foundation (NSF), Social, Behavioral and Economic Sciences Directorate. The report is subject to extensive review by internal and external subject matter experts, federal agencies, Board members, and NCSES statistical reviewers for accuracy, coverage, and balance.

Indicators includes detailed information about measurement to help readers understand what the reported measures mean, how the data were collected, and how to use the data appropriately. The report's data analyses, however, are relatively accessible. The data can be examined in various ways, and the report generally emphasizes neutral, factual description. As a result, *Indicators* almost exclusively uses simple statistical tools. The Methodology Appendix of the report provides detailed information on the methodological, statistical, and data-quality criteria used for the report. The sidebar What Makes a Good Indicator? provides a brief and high-level summary of the data sources used in the report and data-quality issues that influence the interpretation and accuracy of the information presented in *Indicators*.

Indicators 2018 Parts

Indicators 2018 includes an Overview and eight chapters that follow a generally consistent pattern. The chapter titles are as follows:

- Elementary and Secondary Mathematics and Science Education

- Higher Education in Science and Engineering

- Science and Engineering Labor Force

- Research and Development: U.S. Trends and International Comparisons

- Academic Research and Development

- Industry, Technology, and the Global Marketplace

- Science and Technology: Public Attitudes and Understanding

- Invention, Knowledge Transfer, and Innovation

In addition, *Indicators 2018* includes an online data tool, State Indicators, which provides state-level data on science and technology (S&T); and a Digest, comprising a small selection of important indicators from the main report.

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The Board authors one or more companion pieces, which draw on the data in *Indicators* and offer recommendations on various issues related to national science and engineering research or education policy, in keeping with the Board's statutory responsibility to bring attention to such issues.

The Digest

The *Science and Engineering Indicators 2018 Digest* is a condensed version of the report comprising a small selection of important indicators. It is intended to serve readers with varying levels of expertise. The Digest draws attention to important trends and data points and introduces readers to the data resources available in the main report and associated products.

The Overview of the State of the U.S. S&E Enterprise in a Global Context

The Overview highlights information from *Science and Engineering Indicators* that offers insights into the global landscape and presents broadly comparable data to examine indicators across regions, countries, and economies. Like the Digest, the Overview is intended to serve readers with varying levels of expertise. Because the Overview relies heavily on figures, it is well-adapted for use in developing presentations. Like the core chapters, the Overview strives for a descriptive synthesis and a balanced tone, and it does not take or suggest policy positions.

The Eight Core Chapters

Each chapter consists of highlights; introduction (chapter overview and chapter organization); a narrative synthesis of data and related contextual information; sidebars, data tables, and figures; conclusion; notes; glossary; and references.

Highlights. The highlights outline the major dimensions of a chapter topic.

Introduction. The chapter's overview briefly explains the importance of the topic. It situates the topic in the context of major concepts, terms, and developments relevant to the data reported. The introduction includes a brief narrative account of the logical flow of topics within the chapter.

Narrative. The chapter narrative is a descriptive synthesis that brings together significant findings. It is also a balanced presentation of contextual information that is useful for interpreting the findings. The narrative is designed to draw attention to major points and enable readers to readily comprehend a large amount of information. As a balanced presentation, the narrative aims to include appropriate caveats and context to convey appropriate uses of the data and provide contextual information within which the data may be interpreted by users with a range of science policy views.

Figures. Figures provide visually compelling representations of major findings discussed in the text. Figures also enable readers to test narrative interpretations offered in the text by examining the data themselves.

Tables. Data tables help to illustrate and to support points made in the text.

Sidebars. Sidebars discuss interesting recent developments in the field, more speculative information than is presented in the regular chapter narrative, or other special topics. Sidebars can also present definitions or highlight crosscutting themes.

Appendix Tables. An appendix of tabular data provides the most complete presentation of quantitative data, without contextual information or interpretive aids.

Conclusion. The conclusion summarizes important findings. It offers a perspective on important trends but stops short of definitive pronouncements about either likely future trends or policy implications. Conclusions avoid factual syntheses that suggest distinctive or controversial viewpoints.

Notes. Information that augments points of discussion in the text is presented as endnotes.

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Glossary. The glossary defines terms used in the chapter.

References. *Indicators* includes references to data sources cited in the text, emphasizing national or internationally comparable data. The report does not attempt to review the analytic literature on a topic or summarize the social science or policy perspectives that might be brought to bear on it. References to that literature are included where they help to explain the basis for statements in the text.

State Indicators Data Tool

This online tool provides data to assess trends in S&T-related activities in states that can be used by people involved in state-level policy making, journalists, and interested citizens. State-level indicators to call attention to state performance in S&T and foster consideration of state-level activities in this area. Data for the indicators are graphically displayed in tables that detail state data, in U.S. maps that code states into quartiles, and in histograms that show how state values are distributed. Users also have access to long-term trend data for each indicator.

Presentation

The complete content of *Indicators 2018* is available for download. The report is downloadable as a PDF and text tables, appendix tables, and source data for each figure are available in PDF and spreadsheet formats. In addition, figures are also available in presentation-style image files.

Letter of Transmittal

National Science Board

January 15, 2018

MEMORANDUM FROM THE CHAIR OF THE NATIONAL SCIENCE BOARD

TO: The President and Congress of the United States

SUBJECT: Science and Engineering Indicators 2018

As Chair of the National Science Board (Board), it is my honor to transmit, on behalf of the Board, *Science and Engineering Indicators* (*Indicators*) *2018*. The Board submits this biennial report "on indicators of the state of science and engineering in the United States" as required by 42 U.S.C. § 1863 (j) (I). The *Indicators* series provides a broad base of unbiased, quantitative information about the U.S. science and engineering (S&E) enterprise for use by policymakers, researchers, and the public.

The digital report includes information on science, technology, engineering, and mathematics (STEM) education at all levels; the scientific and engineering workforce; U.S. and international research and development performance; U.S. competitiveness in high-technology industries; and public attitudes and understanding of S&E. The report synthesizes several key indicators of the strength of U.S. science and technology in an "Overview of the State of the U.S. S&E Enterprise in a Global Context." *Indicators 2018* also includes an interactive, online tool that enables state comparisons on a variety of S&E indicators.

For the 2018 edition, the Board has introduced a new chapter on "Invention, Knowledge Transfer, and Innovation." This chapter provides data and analysis on several key questions: how does innovation happen; how do we measure it; who are the major players; and how does innovation diffuse through society and economies to contribute to economic growth?

The Board hopes that the Administration and Congress find the information and analysis in the report useful and timely for the planning of national priorities, policies, and programs in science and technology.

Maria T. Zuber

Chair

National Science Board

National Science Board

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Image Credit

The website for *Science and Engineering Indicators 2018 incorporates* a polarization microscope image of liquid crystals. Liquid crystals revolutionized how we present information, giving rise to the liquid crystal display (LCD) industry. Modern devices including smartphones, laptop screens, and flat-panel television sets all feature LCDs, in which so-called nematic ("threadlike") liquid crystals realign in an electric field, thus changing the appearance of the pixelated screen.

In the photo, the two dark centers with emerging streamers are called "boojum," point defects in the molecular orientation of the liquid crystal. The defects form at the surface of a thin film of nematic fluid, the simplest form of a liquid crystal. The bands of different colors show the varying orientation of liquid crystal molecules around the defect.

This image was created by Oleg D. Lavrentovich, Trustees Research Professor, Liquid Crystal Institute and Chemical Physics Interdisciplinary Program, Kent State University. Work at the Liquid Crystal Institute explores the physical mechanisms behind the complex, three-dimensional molecular architectures and the practical applications of these materials. Research in liquid crystals at Kent State University has been supported by a series of National Science Foundation grants (the most recent is NSF award number 17-29509).

Image credit: *Oleg D. Lavrentovich, Liquid Crystal Institute, Kent State University.*

Key to Acronyms and Abbreviations

ACGR: adjusted cohort graduation rate

ACS: American Community Survey

ACS: American Competitiveness Survey

ADEA: Age Discrimination in Employment Act of 1967

AFFOA: Advanced Functional Fabrics of America

AFGR: averaged freshman graduation rate

ANBERD: Analytical Business Enterprise R&D

AP: Advanced Placement

ARC: Average of Relative Citations

ARM: Advanced Robotics for Manufacturing

ARMI: Advanced Regenerative Manufacturing Institute

ARPA-E: Advanced Research Projects Agency–Energy

ARRA: American Recovery and Reinvestment Act

AUTM: Association of University Technology Managers

BEA: Bureau of Economic Analysis

BLS: Bureau of Labor Statistics

BPS: Beginning Postsecondary Students

BRDIS: Business R&D and Innovation Survey

CAGR: compound average annual growth rate

C-BERT: Cross-Border Education Research Team

CEMI: Clean Energy Manufacturing Initiative

CIS: Community Innovation Survey

CPS: Current Population Survey

CRADA: cooperative R&D agreement

CRDC: Civil Rights Data Collection

CREDO: Center for Research on Education Outcomes

DHS: Department of Homeland Security

DMDII: Digital Manufacturing and Design Innovation Institute

DOAJ: Directory of Open Access Journals

DOC: Department of Commerce

DOD: Department of Defense

DOE: Department of Energy

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EACEA: Education, Audiovisual and Culture Executive Agency

EC: European Commission (Overview)

ECDS: Early Career Doctorates Survey

ECLS-K: Early Childhood Longitudinal Study-Kindergarten

ED: Department of Education

EPA: Environmental Protection Agency

EPSCoR: Established Program to Stimulate Competitive Research

ESSA: Every Student Succeeds Act

EU: European Union

FDI: foreign direct investment

FedScope: Federal Human Resources Data

FFRDC: federally funded research and development center

FLC: Federal Laboratory Consortium for Technology Transfer

FTE: full-time equivalent

FY: fiscal year

G20: Group of Twenty

GAO: Government Accountability Office

GBARD: government budget appropriations for R&D

GDP: gross domestic product

GE: genetically engineered

GED: General Educational Development

GERD: gross domestic expenditures on R&D

GHG: greenhouse gas

GM: genetically modified

GMO: genetically modified organism

GMU: George Mason University

GPT: general purpose technology

GSS: General Social Survey

GSS: Survey of Graduate Students and Postdoctorates in Science and Engineering

GUF: general university fund

HBCU: historically black college or university

HDI: Human Development Index

HE: higher education

HERD: Higher Education Research and Development Survey

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HHE: High Hispanic enrollment

HHS: Department of Health and Human Services

HPC: high-performance computing

HS: Harmonized Commodity Description and Coding System, or Harmonized System

HSI: Hispanic-serving institution

HSLS: High School Longitudinal Study

HT: high technology

IACMI: Institute for Advanced Composites Manufacturing Innovation

IB: International Baccalaureate

ICT: information and communications technologies

IDeA: Institutional Development Award

IEA: International Association for the Evaluation of Educational Achievement

IEA: International Energy Agency

IIE: Institute of International Education

IMF: International Monetary Fund

IOF: involuntarily out-of-field

IoT: Internet of Things

IPC: International Patent Classification

IPEDS: Integrated Postsecondary Education Data System

IPO: initial public offering

IPUMS: Integrated Public Use Microdata Series

IRC: Internal Revenue Code

IRS: Internal Revenue Service

ISCED: International Standard Classification of Education

ISCED-F: ISCED Fields of Education and Training

ISIC: International Standard Industrial Classification of All Economic Activities

ISO: International Organization for Standardization

IT: information technology

ITC: Investment Tax Credit

IUCRC: Industry–University Cooperative Research Centers Program

K–12: kindergarten through 12th grade

KI: knowledge intensive

KTI: knowledge- and technology-intensive

LIFT: Lightweight Innovations for Tomorrow

Front Matter

MEP: Manufacturing Extension Partnership

MER: market exchange rate

MFP: multifactor productivity

MHT medium-high technology

MIT: Massachusetts Institute of Technology

MNC multinational corporation

MNE: multinational enterprise

MOOC: massive open online course

MSI: minority-serving institution

NAEP: National Assessment of Educational Progress

NAFTA: North American Free Trade Agreement

NAGB: National Assessment Governing Board

NAICS: North American Industry Classification System

NASA: National Aeronautics and Space Administration

NASF: net assignable square feet

NCES: National Center for Education Statistics

NCRPA: National Cooperative Research and Production ActNCSES: National Center for Science and Engineering Statistics

NCTQ: National Center for Teaching Quality

nec: not elsewhere classified

NECTA: New England City and Town Area

NEH: National Endowment for the Humanities

NELS: National Education Longitudinal Study

NGA: National Governors Association

NGSS: Next Generation Science Standards

NIH: National Institutes of Health

NIIMBL: National Institute for Innovation in Manufacturing Biopharmaceuticals

NIPA: national income and product accounts

NIST: National Institute of Standards and Technology

NLR: National Lambda Rail

NLS: National Longitudinal Study

NOAA: National Oceanic and Atmospheric Administration

NPL: nonpatent literature

NPSAS: National Postsecondary Student Aid Study

NRC: National Research Council

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NSB: National Science Board

NSCG: National Survey of College Graduates

NSCI: National Strategic Computing Initiative

NSF: National Science Foundation

NSLP: National School Lunch Program

NSRCG: National Survey of Recent College Graduates

NTIA: National Telecommunications and Information Administration

NTPS: National Teacher and Principal Survey

OA: open access

OECD: Organisation for Economic Co-operation and Development

OES: Occupational Employment Statistics

ONP: other nonprofit organization

OPEC: Organization of the Petroleum Exporting Countries

OPM: Office of Personnel Management

OPT: optional practical training

OSTP: Office of Science and Technology Policy, Executive Office of the President

OWH: other Western Hemisphere

PISA: Program for International Student Assessment

PPP: purchasing power parity

PSM: Professional Science Master's

PST: professional, scientific, and technical

PTC: Production Tax Credit

R&D: research and development

R&E: research and experimentation

RA: research assistantship

RAPID: Rapid Advancement in Process Intensification Deployment

RC: relative citation

RD&D: research, development, and demonstration

REMADE: Reducing Embodied-energy and Decreasing Emissions in Materials Manufacturing

ROW: rest of world

S&E: science and engineering

S&T: science and technology

SASS: Schools and Staffing Survey

SBA: U.S. Small Business Administration

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SBIR: Small Business Innovation Research

SciELO: Scientific Electronic Library Online

SDR: Survey of Doctorate Recipients

SED: Survey of Earned Doctorates

SEH: science, engineering, and health

SEP: standard essential patent

SES: socioeconomic status

SESTAT: Scientists and Engineers Statistical Data System

SET: science, engineering, and technology

SEVIS: Student and Exchange Visitor Information System

SOC: Standard Occupational Classification

STEM: science, technology, engineering, and mathematics

STTR: Small Business Technology Transfer

TA: teaching assistant

TCU: tribal college or university

TEL: technology and engineering literacy

TFP: total factor productivity

TIMSS: Trends in International Mathematics and Science Study

UIS: UNESCO Institute for Statistics

UK: United Kingdom

UN: United Nations

UNESCO: United Nations Educational, Scientific and Cultural Organization

URM: underrepresented minority (black or African American, Hispanic or Latino, and American Indian or Alaska Native)

USCIS: U.S. Citizenship and Immigration Services

USDA: Department of Agriculture

USPTO: U.S. Patent and Trademark Office

WebCASPAR: Integrated Science and Engineering Resources Data System

WIPO: World Intellectual Property Organization

WTO: World Trade Organization

XSEDE: Extreme Science and Engineering Discovery Environment