The Right Prescription: Policy Priorities for Advancing Innovation in U.S. Biopharmaceutical Manufacturing

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- The world's leading science and technology policy think tank.
- Supports policies driving global, innovation-based economic growth.
- Focuses on issues at the intersection of technology innovation and public policy across several sectors:
  - Innovation and competitiveness
  - IT and data
  - Telecommunications
  - Trade and globalization
  - Clean energy, manufacturing, life sciences, and ag biotech



ITIF Advocacy for U.S. Advanced/(Bio)Manufacturing

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The Case for a National Manufacturing Strategy

BY STEPHEN J. EZELL AND ROBERT D. ATKINSON

APRIL 2011

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The Information Technology & Innovation Foundation

Why America Needs A National Network for Manufacturing Innovation

BY DAVID M. HART, STEPHEN J. EZELL, AND ROBERT D. ATKINSON | DECEMBER 2012

A National Network for Manufacturing Innovation (NNMI) could play a pivotal role in spurring U.S. industrial competitiveness and revitalizing American manufacturing.

The United States lacks an integrated, well-funded national network of large-scale, industry-led manufacturing innovation centers. Leading manufacturing nations around the world, from Germany to Taiwan, have such centers, which accelerate technology deployment, operate demonstration facilities and test beds, support education and training, and perform applied research on new manufacturing processes, among other activities. The proposed National Network for Manufacturing Innovation (NNMI) would fill this void. This report explains why action on this proposal is vital to U.S. manufacturing competitiveness and worthy of investment even in a time of tight budget constraints. It then articulates key principles that should guide the development of the NNMI.

EXECUTIVE SUMMARY

America needs a National Network for Manufacturing Innovation. This paper sets forth the argument for this proposition in two parts. The first part makes the case for an innovation-centered national manufacturing policy. It lays out key challenges facing the U.S. manufacturing sector, advances reasons why the nation should care about manufacturing, and sets forth the rationale for an active federal role in fostering manufacturing innovation. Crucially, this role should be catalytic, not directive; federal actions should spur other key players, especially the private sector, into action and foster stronger collaboration among them.

INNOVATION FILES
Quick takes, quips, and commentary on the latest in tech policy

RAMI Legislation Poised to Revitalize American Manufacturing

By Stephen Ezell | July 24, 2014



This Friday morning, July 25, the House Committee on Space, Science, and Technology will hold a full Committee markup of H.R. 2996, the Revitalize American Manufacturing and Innovation (RAMI) Act of 2013. This is the House's companion legislation to Senate Bill 1468, which passed out of the Senate Commerce, Science, and Transportation Committee by voice vote in May.

The legislation would provide authorization, using existing funding of up to $300 million, for the Secretary of Commerce to establish up to 15 Institutes of Manufacturing Innovation (IMIs), public-private partnerships that would focus on developing advanced manufacturing product and process technologies, facilitating their commercialization, and developing workforce skills around advanced manufacturing technologies. As ITIF writes in *Why America Needs a National Network for Manufacturing Innovation (NNMI) and How It Should Work*, these institutes would play a pivotal role in enhancing U.S. industrial competitiveness by supporting development of technologies that will enable U.S. manufacturers to compete in the global marketplace. The additional IMIs would join four already chartered focusing on additive manufacturing, next-generation power electronics, digital manufacturing and design innovation, and lightweight and modern metals manufacturing, all of which are developing manufacturing technologies with both commercial and mission-oriented (i.e., federal agency) applications.

The RAMI legislation makes it possible for new Institutes proposed by U.S. industry and competitively selected on a technology-neutral basis by the National Institutes of Standards and Technology (NIST) to be established. The legislation requires that proposing consortia finance at least 50 percent of the cost of each new Institute and specifies that the intent of the federal match is to get the Institutes established; they must be self-sustaining within seven years.

The RAMI legislation makes possible an institutional structure to support advanced manufacturing in the United States that virtually every major American manufacturing competitor nation already enjoys, with their governments making substantial investments in similar institutes. For example, a recent *Wall Street Journal* articleExplaining Germany's Success Story in Manufacturing credits in large part Germany's network of 67 Fraunhofer Institutes that "have helped make Germany one of the leading exporters of high-tech manufactured goods." Germany invests $2.75 billion *per year* in its Fraunhofer Institutes, two-thirds of which ($1.8 billion) comes from federal-state governments (through a combination of direct funding, grants, and contracting its own research needs to the Institutes). Britain's total public-private sector investment in its Catapult Centers—a network of seven technology and innovation centers covering a range of sectors: High Value Manufacturing, Satellite Applications, Cell Therapy, Offshore Renewable Energy, Future Cities, Transport Systems and the Connected Digital Economy—has so far reached £1.4 billion ($2.4 billion). Even still, just yesterday, UK Business Secretary Vince Cable admitted that "the British government still isn't doing enough to support innovation" and called for a doubling of funding for UK's Technology Strategy Board to £1 billion. Cable highlighted the vital role of public private partnerships (i.e. Britain's Catapults) in developing advanced manufacturing product and process technologies, noting that "Critical as it is to have a healthy, profitable private sector, it will not, on its own, generate large scale innovation in areas where there are higher risks and wider benefits."

Elsewhere, Ontario, Canada has launched a $200 million advanced manufacturing fund. In other words, two-thirds of what the U.S. would fund with RAMI's $300 million authorization is being invested in *just one Canadian province*. Japan's $117 billion economic stimulus package, introduced in January 2013, included $2 billion specifically to promote university-industry collaboration, including money to equip universities to conduct industrially relevant research. And, as part of its Horizon 2020 program, the European Union (EU) has committed €17 billion ($23 billion (@$4B/year)) for "leadership in deploying six key enabling and industrial technologies" including advanced manufacturing, advanced materials, nanotechnology, micro-electronics, and photonics. Just as with America's IMIs, the EU's investments will focus on technology development, industrial-scale pilots and test-beds, and prototyping/product validation. And this follows on the EUs FY'13 Funding of €230 million ($310 million) for its "Factories of the Future" program. France also invests heavily in its Industrial Technology Institutes. And while China doesn't have manufacturing institutes, *per se*, it is only putting $1.7 trillion into its seven key "strategic and emerging industries" through 2020, including $245 billion to support China's high-end equipment manufacturing sector *alone*.

Manufacturing USA Institutes, By Technology Groups

Electronics

Integrated Photonics
Albany, NY
Rochester, NY

Flexible Hybrid Electronics
San Jose, CA

Wide Bandgap Semiconductors
Raleigh, NC

Materials

Advanced Fibers and Textiles
Cambridge, MA

Advanced Composites
Knoxville, TN
Detroit, MI

Lightweight Materials
Detroit, MI

Energy/Environment

Modular Chemical Process Intensification
New York, NY

Sustainable Manufacturing
Rochester, NY

Smart Manufacturing
Los Angeles, CA

Electrified Processes for Industry Without Carbon
Phoenix, Arizona

Digital /Automation

Additive Manufacturing
Youngstown, OH
El Paso, TX

Robotics & AI
Pittsburgh, PA

Digital Manufacturing & Cybersecurity
Chicago, IL

Cybersecurity in Manufacturing
San Antonio, TX

Bio-Manufacturing

Regenerative Manufacturing
Manchester, NH

Biopharmaceutical Manufacturing
Newark, DE

Bioindustrial Manufacturing
St. Paul, MN

Upcoming

New AI Institute – 2024 award

Digital Twin Semiconductor Manufacturing Institute – 2024 award

Up to two more new NIST institutes on semiconductor manufacturing

U.S. Can Lose Advanced Industry Competitiveness

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Going, Going, Gone? To Stay Competitive in Biopharmaceuticals, America Must Learn From Its Semiconductor Mistakes

STEPHEN J. EZELL | NOVEMBER 2021

America has lost 70 percent of its semiconductor manufacturing capacity over the last three decades. That serves as a harsh lesson for policymakers: Failing to maintain a supportive policy environment could set up other high-tech industries to falter, too.

KEY TAKEAWAYS

- The United States has a long history of being the first to develop innovative industries, but then losing production to other nations. Process and product innovations are joined at the hip, so the result is industries become innovation laggards.
- The underlying erosion of U.S. manufacturing in industries like semiconductors, solar panels, and telecom equipment has often resulted from foreign governments "buying industry share" with subsidies, and U.S. policymakers have failed to respond.
- Some contend it's acceptable to lose leadership in innovation industries, because we'll just create new ones. But intensifying global competition, notably from China, makes such indifference untenable.
- America created the semiconductor industry, lost global leadership in the 1970s, then regained it with effective policies in the 1980s. But inattentiveness in recent decades has led once again to erosion, requiring a new, $50 billion CHIPS package.
- Similarly, America was once a global "also-ran" in biopharmaceutical innovation, but it became the leader with policies like robust R&D investments, IP protections, and drug-pricing systems that enabled innovators to earn profits to reinvest.
- Now the U.S. policy environment for biopharma innovation and production is in danger of eroding with calls to impose drug price controls, weaken IP protections, and roll back supportive tax credits. Policymakers should avoid making those mistakes.

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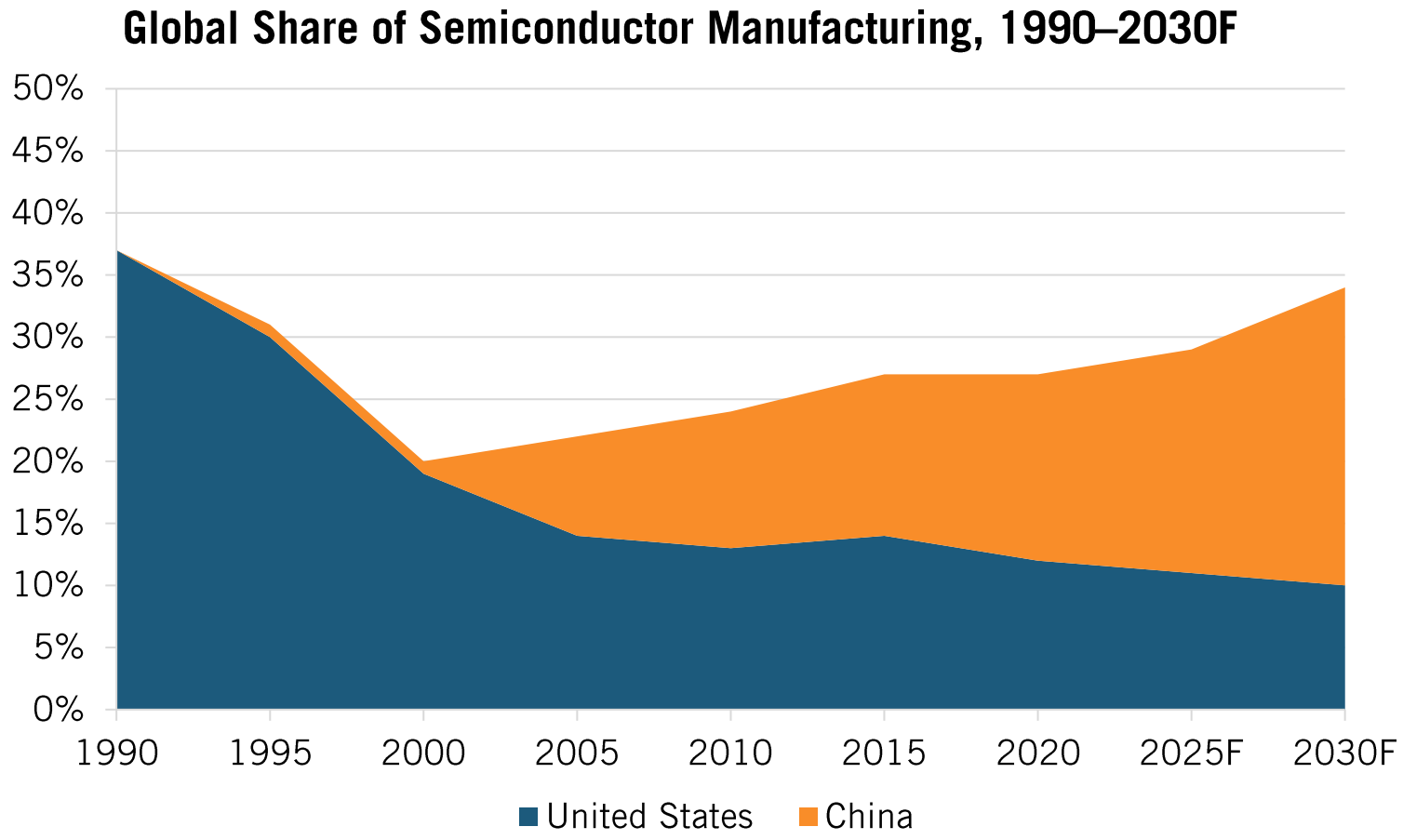
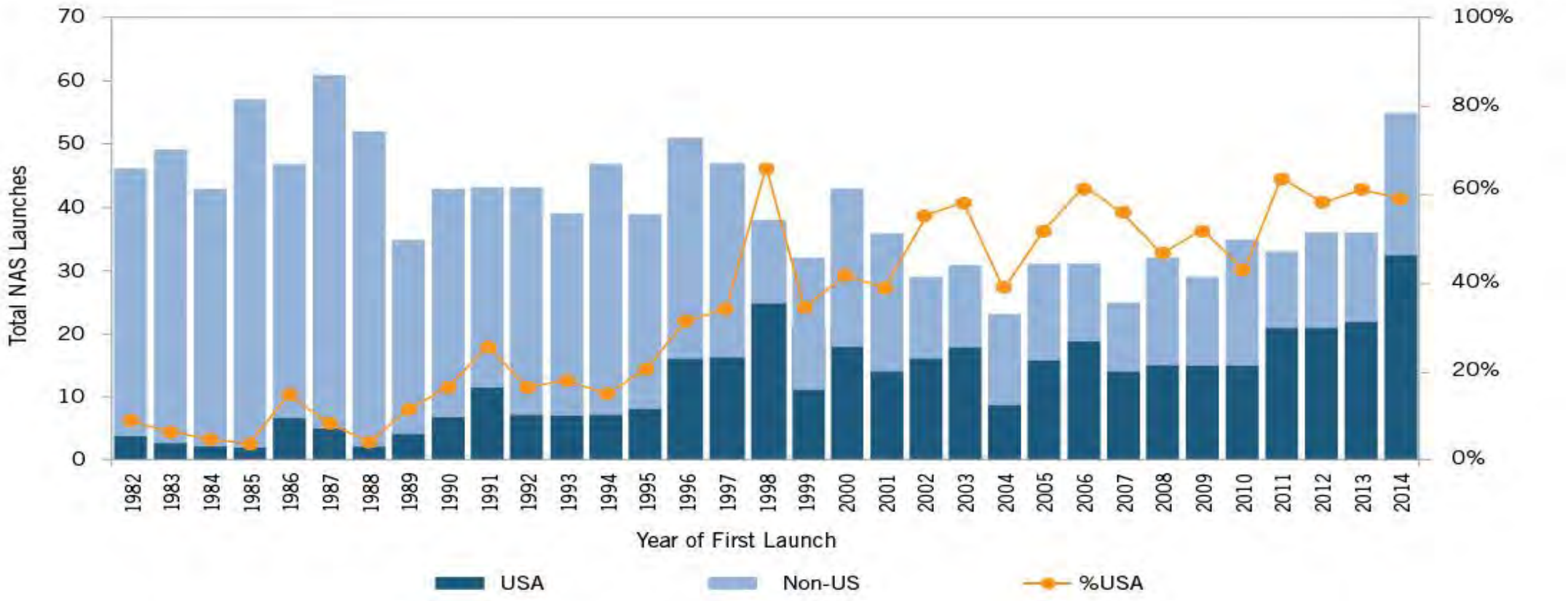


Source: ITIF, "Going, Going, Gone? To Stay Competitive in Biopharmaceuticals, America Must Learn From Its Semiconductor Mistakes"

U.S. Life-Sciences Leadership A Recent Phenomenon

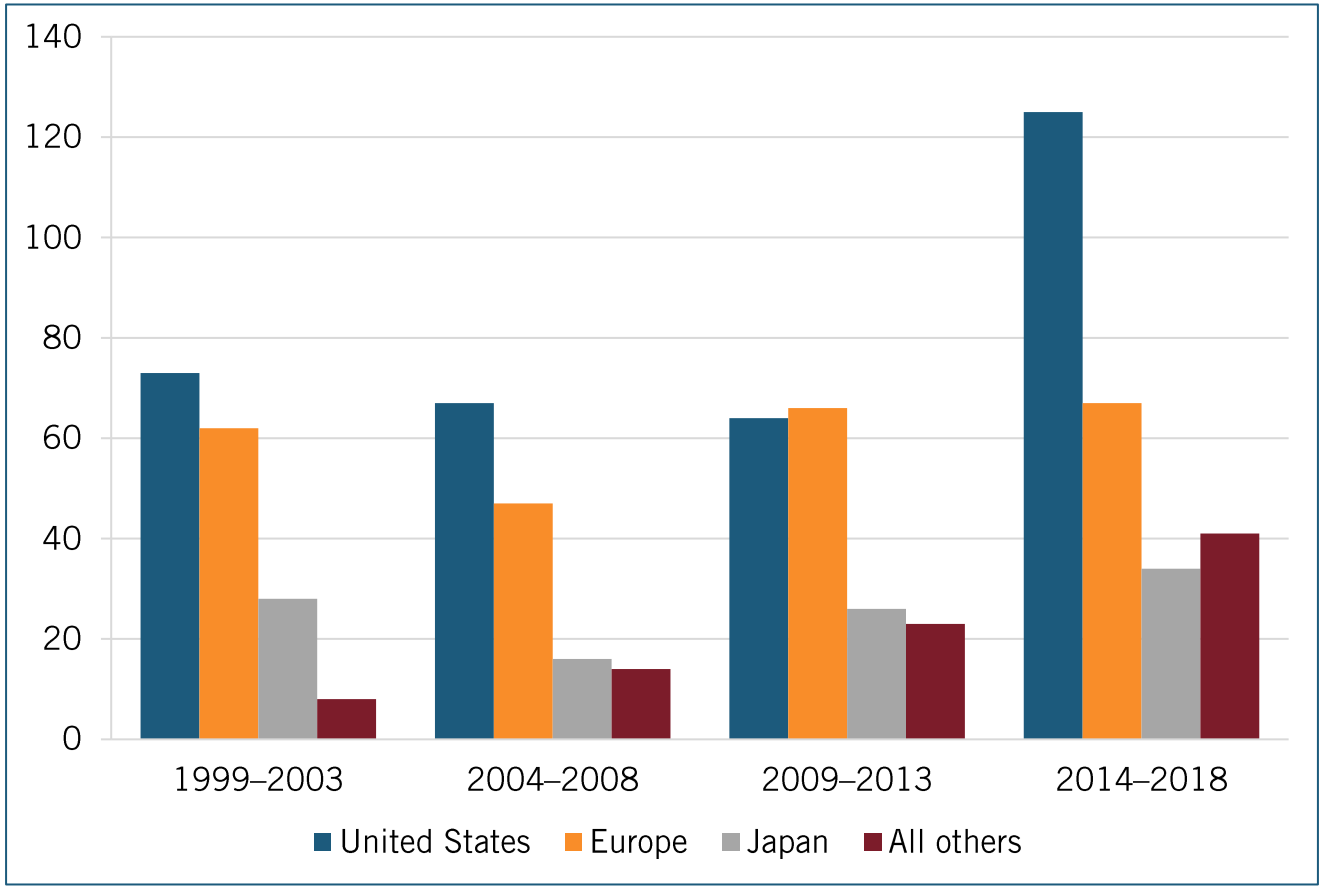
U.S. Share of New Active Substances (NAS) Launched First on World Market



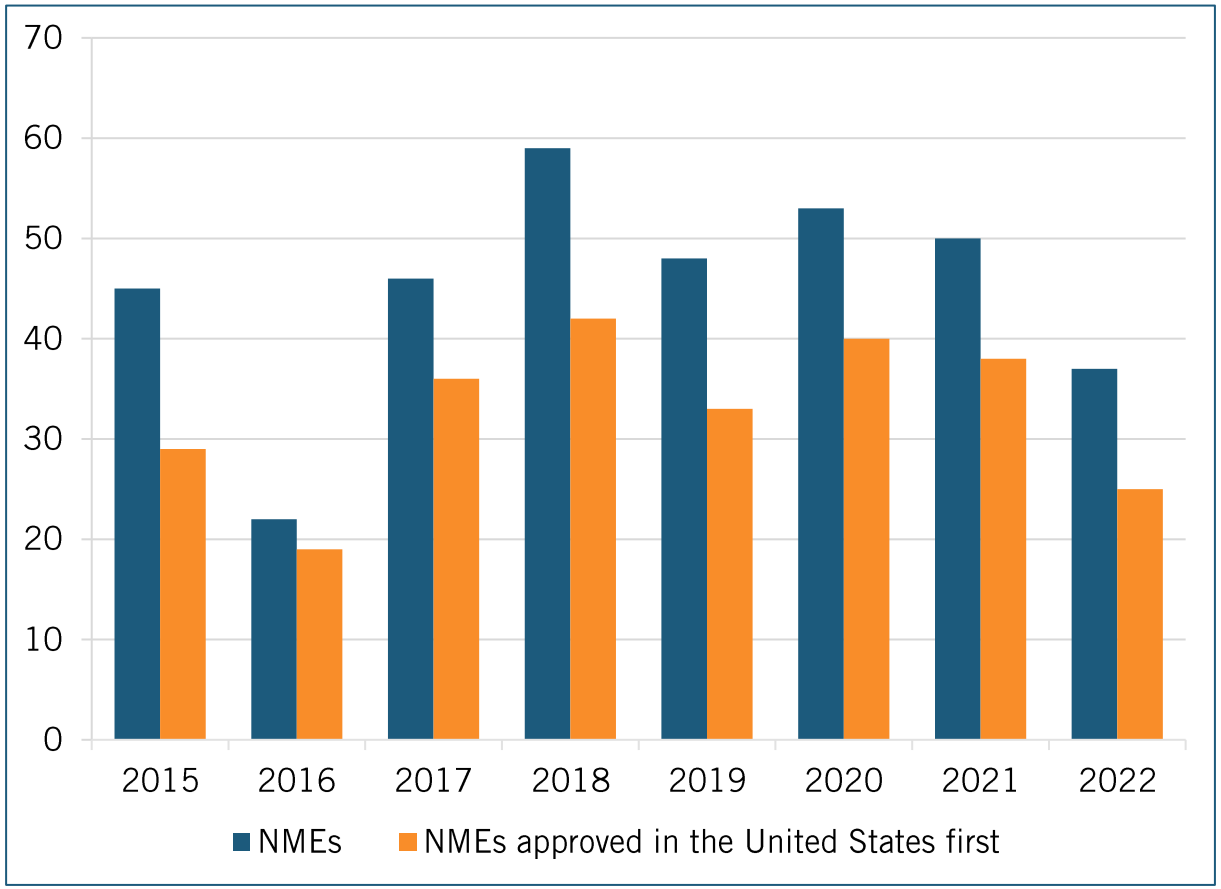
Source: John K. Jenkins, M.D., "CDER New Drug Review: 2015 Update

U.S. Did Become Global Life Sciences Innovation Leader

Number of New Biological or Chemical Entities Introduced



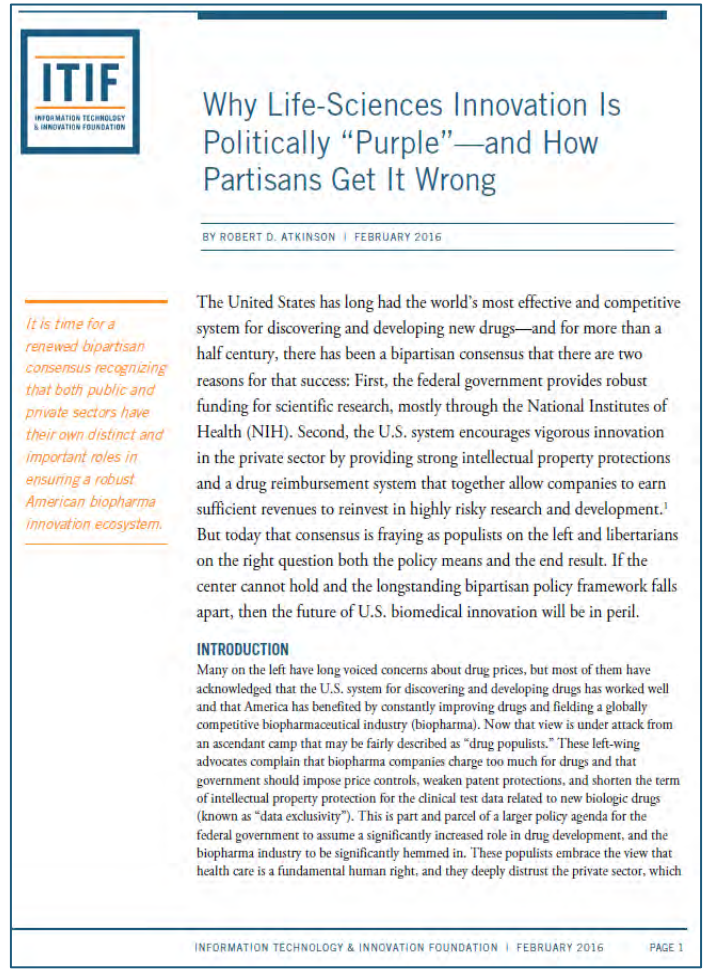
 # New U.S. NMEs and Those Introduced First in United States



Source: ITIF, "Not Again: Why the United States Can't Afford to Lose Its Biopharma Industry"

Keys to U.S. Life-Sciences Innovation Leadership

1. Robust public/private investment in biomedical research.
2. Effective institutions supporting biomedical research.
3. Aggressive incentives to encourage investment. (E.g., R&D tax credit, Orphan Drug Tax Credit)
4. Effective regulatory/drug approval system (PDUFA).
5. Robust intellectual property protections.
6. Pricing system allowing innovators to earn revenues.



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Why Life-Sciences Innovation Is Politically "Purple"—and How Partisans Get It Wrong

BY ROBERT D. ATKINSON | FEBRUARY 2016

It is time for a renewed bipartisan consensus recognizing that both public and private sectors have their own distinct and important roles in ensuring a robust American biopharma innovation ecosystem.

The United States has long had the world's most effective and competitive system for discovering and developing new drugs—and for more than a half century, there has been a bipartisan consensus that there are two reasons for that success: First, the federal government provides robust funding for scientific research, mostly through the National Institutes of Health (NIH). Second, the U.S. system encourages vigorous innovation in the private sector by providing strong intellectual property protections and a drug reimbursement system that together allow companies to earn sufficient revenues to reinvest in highly risky research and development.[1] But today that consensus is fraying as populists on the left and libertarians on the right question both the policy means and the end result. If the center cannot hold and the longstanding bipartisan policy framework falls apart, then the future of U.S. biomedical innovation will be in peril.

INTRODUCTION

Many on the left have long voiced concerns about drug prices, but most of them have acknowledged that the U.S. system for discovering and developing drugs has worked well and that America has benefited by constantly improving drugs and fielding a globally competitive biopharmaceutical industry (biopharma). Now that view is under attack from an ascendant camp that may be fairly described as "drug populists." These left-wing advocates complain that biopharma companies charge too much for drugs and that government should impose price controls, weaken patent protections, and shorten the term of intellectual property protection for the clinical test data related to new biologic drugs (known as "data exclusivity"). This is part and parcel of a larger policy agenda for the federal government to assume a significantly increased role in drug development, and the biopharma industry to be significantly hemmed in. These populists embrace the view that health care is a fundamental human right, and they deeply distrust the private sector, which

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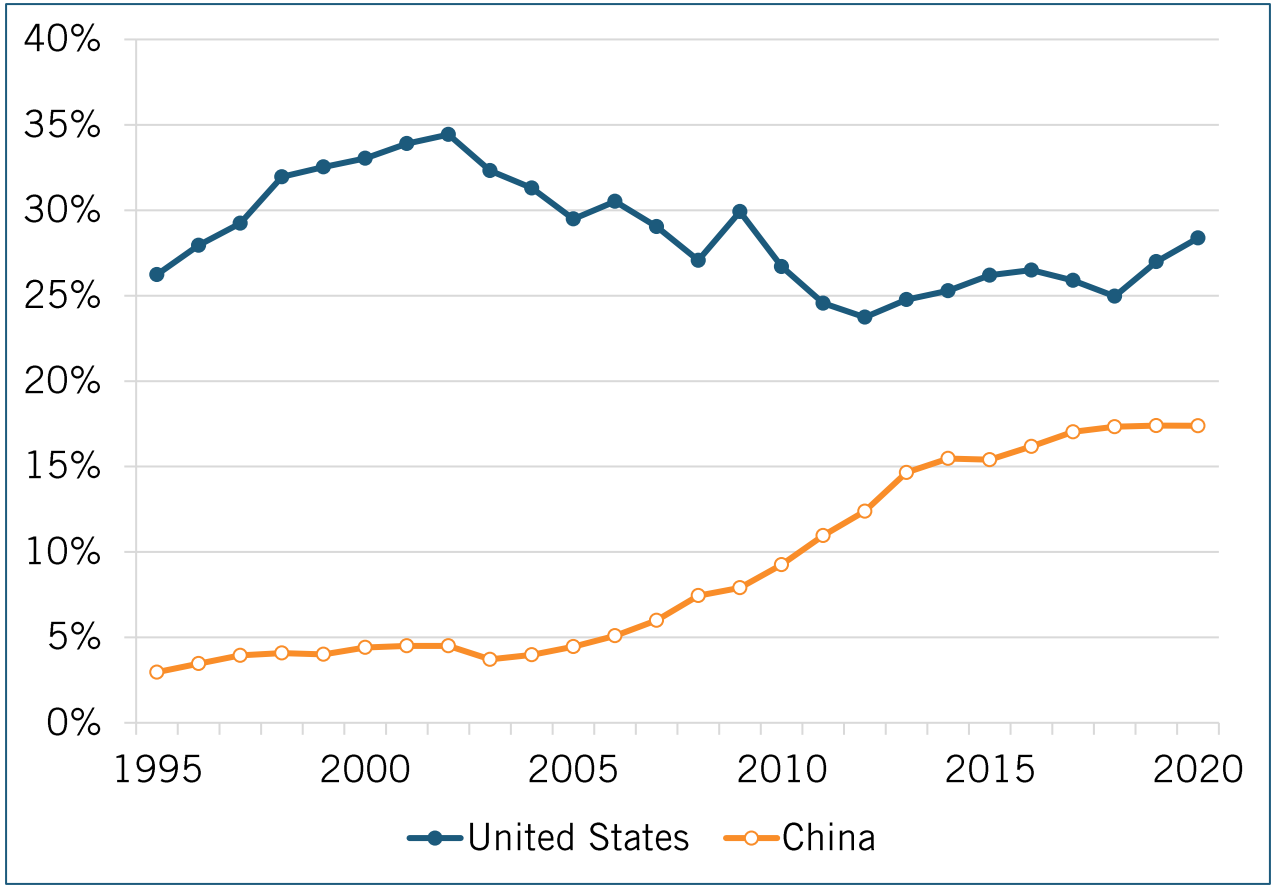
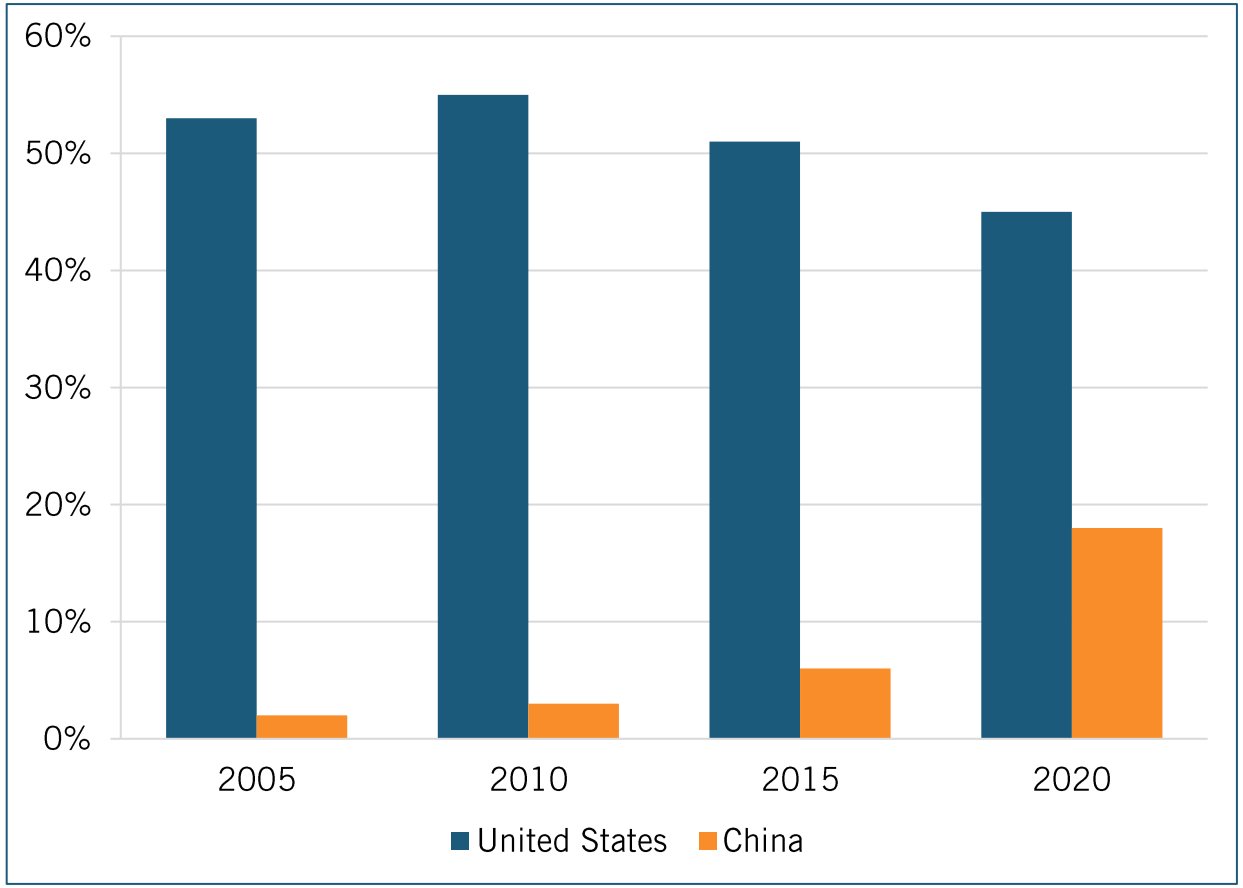
Source: ITIF, "Why Life-Sciences Innovation is "Politically Purple"—And How Partisans Get It Wrong"

But U.S. Life-Sciences Leadership Is Also Not Assured

Share of Global Biopharmaceutical Output, 1995–2020

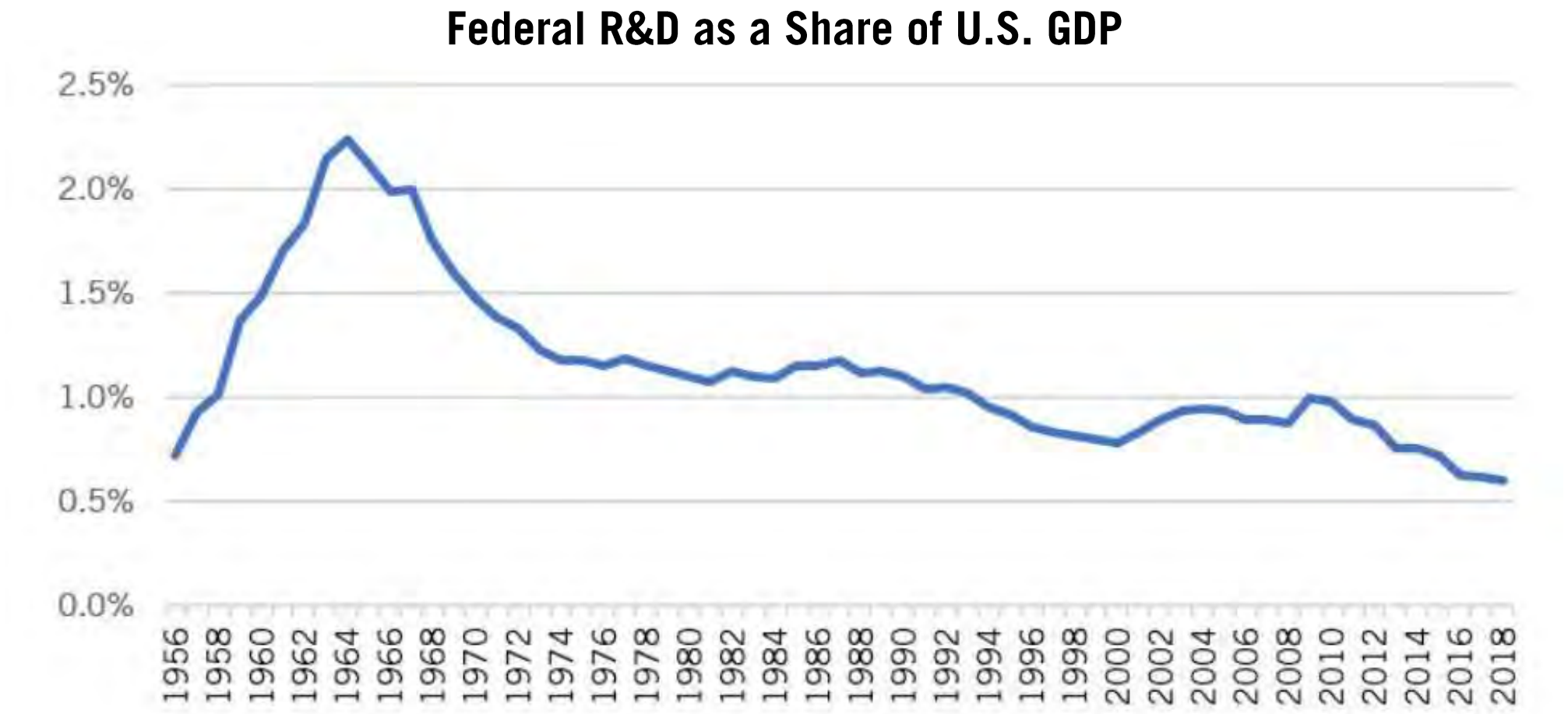


Share of New Oncology Drugs Under Development, 2005–2020



Source: ITIF, "Not Again: Why the United States Can't Afford to Lose Its Biopharma Industry"

Ignominious Slide in Federal R&D Funding



ITIF and “The CHIPS and Science Act of 2022”









Why America Needs Semiconductor Legislation to Bolster Its Economic and National Security

By Stephen Ezell | January 24, 2022

CHIPS and Science Act of 2022: Top-Line Funding

- Total of $200 billion ***authorized*** for science activities FY 23-27.
- @$81 billion FY 23-27 for NSF: $61 billion for core science R&D activities and $20 billion for a new directorate focused on technology transfer and commercialization activities.
- $52 billion in CHIPS, ***appropriated.*** ($39B grants; $11B R&D; $24B ITC).



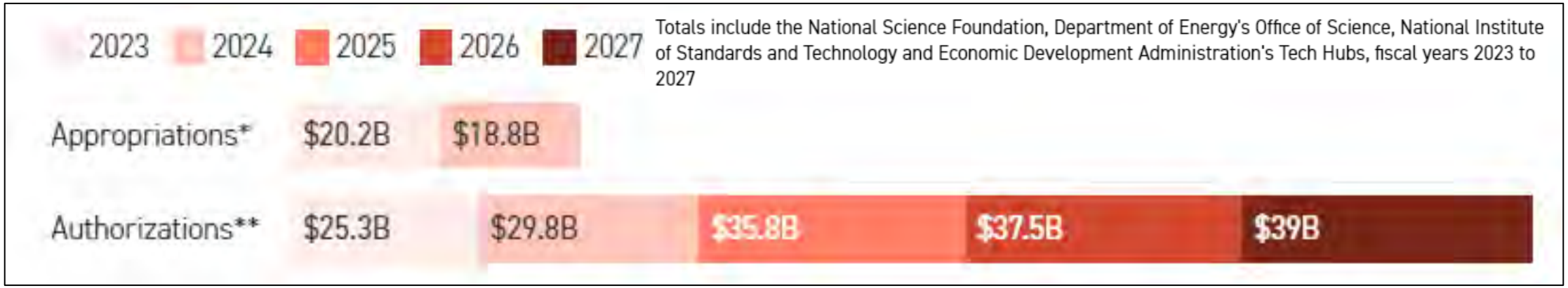


The Bioeconomy Research and Development Act

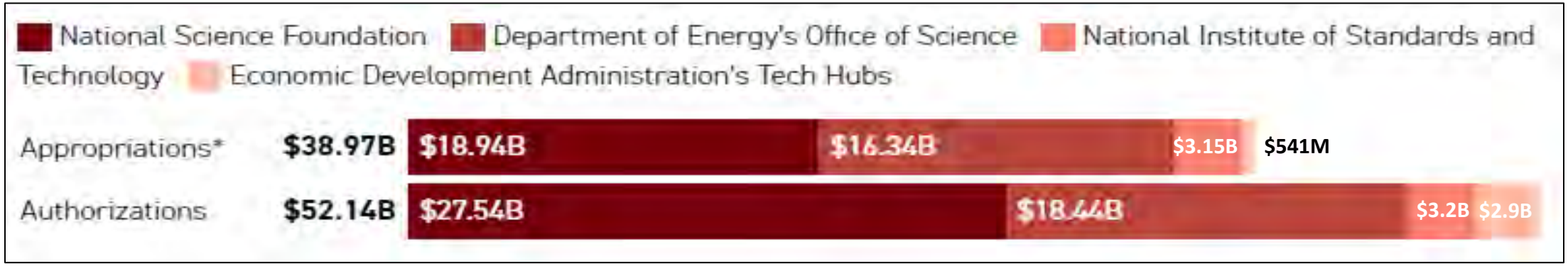
- Established a federal engineering biology research initiative.
- Required a national strategy for investments and development of a framework for interagency coordination.
- Expanded education and training for the next generation of engineering biology researchers.
- Directs U.S. to lead global discussions about responsible development and governance of emerging biotechnologies.

CHIPS and Science Act: Science Funding

Appropriations vs. CHIPS & Science Authorizations, FY 2023–2024



Appropriations vs. CHIPS & Science Authorizations, By Selected Agency, FY 2023–2024



Source: Christine Mui, ***Politico***, "How Congress Defanged Biden's Big Science Push"

CHIPS and Science Act: Science Funding Key Takeaways

- NSF should have received $15.64B in FY 24 according to CHIPS, will get $9.06B, 40% below CHIPS authorization; 8% below prior year.
- NIST's $1.16B drops 8% vs. prior year, 11% below CHIPS target.
- Collectively, NSF, NIST, and DoE Office Science are $8 billion below CHIPS authorization targets set for FY 24.



The Economic Impact of Biomanufacturing in the U.S.

- U.S. bioeconomy is valued at over $950B; biopharmaceuticals $560B.
- Biopharmaceutical mfg. employs 308K Americans (38% of 811K total).
- U.S. biopharma mfg. offers good-paying jobs: 25% higher than U.S. average.
- World's most R&D-intensive industry; accounts for @20% U.S. R&D.
- 23% of America's biopharma workforce in R&D; 25% of all U.S. R&D workers.
- Women accounted for over half all R&D employees in pharma manufacturing in 2020, the highest % of for any sectors with at least 100K R&D workers.

Impact of the Coming "Bio Revolution"

- Biomolecules, biosystems, biocomputing, biointerfaces.
- 60% of world's physical inputs could be made using biological processes.
- 45% of world's disease burden could be addressed.
- $2-$4 trillion annual global economic impact 2030-2040.
- Significant increases in biomedical R&D productivity.



Biomanufacturing Applications: Life Sciences





Novel bio-based manufacturing processes enable the biosynthesis of APIs through bio-brewing-based processes, which leverage yeast to create medicinal alkaloids for key APIs.

DARPA is developing a “pharmacy on demand,” capable of producing 1,000 distinct pharmaceutical drugs in 24 hours.

Pfizer’s portable manufacturing platforms allow it to produce vaccines for children in countries where they’re needed most.

Biomanufacturing Applications: Life Sciences

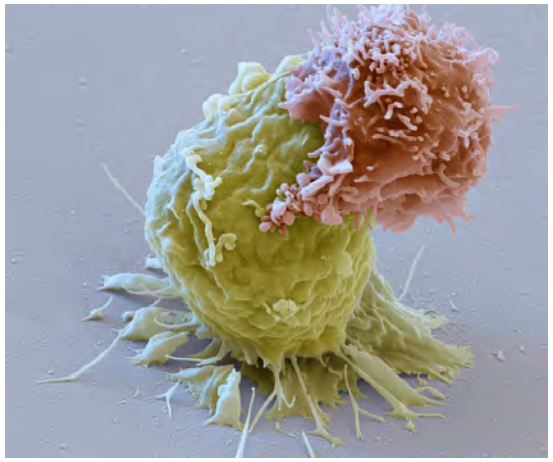


Image of a CAR-T cell (reddish) attacking a leukemia cell (green).

Biomanufacturing of cell therapies, including CAR-T cell therapy and stem cell therapy, to treat diseases such as cancer, autoimmune diseases, and neurological disorders.



Biomanufacturing techniques used for tissue engineering, to grow tissues for transplantation (e.g., engineered skin grafts for burn victims).

Enhancing Resilience in Generic Drug Production

- "No governmental or private sector organization, from DOD to health systems, is certain how many and which of its drugs come from China."
- In 2000, U.S. or European nations were API suppliers for 64% of generic drug filings to the FDA, by 2021 just 11%; China and India 85%.
- Innovative continuous manufacturing processes (vs. batch processing) can help address this challenge.



Source: Olivia Webb Kosloff, "A National Defense Strategy for Generic Drugs," ***American Affairs Journal***, Summer 2024

Biomanufacturing Applications: Other Industries



Bio-based composites to create lighter and more fuel-efficient vehicles; bio-based resins enhance strength, durability, sustainability, reduce CO_2.



Potential of neuromorphic computing; bioinspired storage; organic polymers can be used in fabrication/ATP; ultra-high thermal switching.



Bioreactors and cell culture media to produce cultured meat and provide sustainable, ethical, and scalable meat production methods.



Microbial biomanufacturing to produce essential resources (e.g., nutrients, medicines) during long-duration space missions.

White House Bioeconomy Executive Order (2022)

- **Goal:** Create national framework to leverage bio-based innovations for growth.
  - Includes instructions to implementing agencies, commands to develop specific plans to implement EO, to report back to entities with budgeting authority, and to follow up with reports to show compliance.
- **Outputs:** Tools and reports to guide this sector (Bioeconomy EO Tracker, FAS)
- **Still to Do:** Foundational pieces underpinning bioeconomy strategy yet to be established:
  - Consensus on scope of U.S. bioeconomy and how to measure different aspects of bioeconomy.
  - Development of an updated classification system to accurately analyze bioeconomy.
  - Increased capacity of federal agencies to analyze bioeconomy, synergistic interoperability between them.
  - A coordinating body within the federal government to oversee and guide bioeconomy.

WH Actions to Support Domestic Pharma Manufacturing



- September 2022: Announced $40M to expand role of biomfg. in domestic production of APIs, antibiotics, and other critical materials for essential meds.
- March 2023: OSTP published "Bold Goals for U.S. Biotech and Biomanufacturing," outlining a vision for what's possible/R&D needed to get there.
  - Harness biotech and biomanufacturing to further goals around climate change solutions, food and agriculture innovation, supply chain resilience, human health, and cross-cutting advances. Set national targets to help establish key R&D priorities.
  - Bold goals for human health: Accessible health monitoring, precision multi-omic medicine, biomanufacturing of cell-based therapies, AI-driven bioproduction of therapeutics, advanced techniques in gene editing.

WH Actions to Support Domestic Pharma Manufacturing

- November 2023: WH expanded HHS's authority to invest in domestic manufacturing of essential medicines.
  - HHS to commit $35M to bolster the strength of domestic supply chain for essential medicines.
- December 2023: "Data for the Bioeconomy Initiative" will ensure high-quality, accessible, secure biological data to advance U.S. bioeconomy (Interagency Working Group on Data for the Bioeconomy).
- March 2024: WH launched the National Bioeconomy Board to advance U.S. biotech and biomanufacturing competitiveness.
  - The Board will work with partners across public and private sectors to advance national security, sustainability and competitiveness through biotech and biomanufacturing.
- WH support helps catalyze investment. Since start of Biden administration, private companies have announced over $20 billion in U.S. biomanufacturing investments.

Active Biomanufacturing Legislation

- Agility in Manufacturing Preparedness Act (S. 36)
  - Directs NIIMBL/HHS to review current domestic biopharmaceutical manufacturing capacity and develop new domestic biopharmaceutical manufacturing technologies.
- Biomanufacturing and Jobs Act (S. 2452 & HR 5134)
  - Strengthen domestic mfg. of bio-based products, expand role of Dep. Ag in promotion of biobased products, increase federal purchases of biobased products.
- MMEDS Act of 2023 (S. 33 & HR 447)
  - Relocate medical mfg. facilities (e.g., drugs and devices) to economically distressed zones (with an income tax credit for 40% of the sum of wages paid).

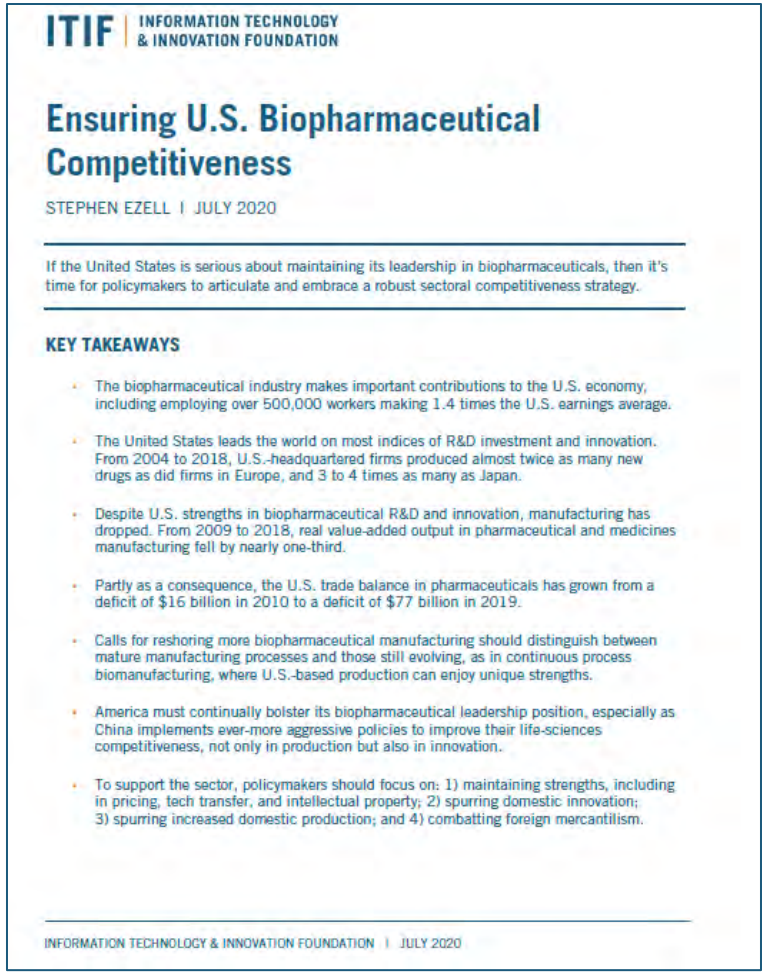
ITIF Tech Policy Recommendations for Next Administration

- ✓ Double the R&D tax credit and restore first-year expensing.
- ✓ Create a "CHIPS Act" for the biopharmaceutical industry.
- ✓ Extend the "CHIPS" 25% investment tax credit to biomfg.
- ✓ Launch a joint industry-university-government R&D partnership to reduce the cost of drug dev./production.
- ✓ Build Mfg. USA out to originally planned 45 institutes.



Policy Recommendations for U.S. Biopharma Competitiveness

- ✓ Fund more biomanufacturing-focused NSF Industry-University Cooperative Research Centers (I/UCRCs).
- ✓ Increase funding for NSF Engineering, especially the Chemical Process Systems and Engineering Biology & Health Clusters.
- ✓ Expand the Manufacturing Engineering Education program and NSF Advanced Technical Education (ATE) program.
- ✓ Restore the tax credit for biopharma production in Puerto Rico and the U.S. territories (Section 936).



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Ensuring U.S. Biopharmaceutical Competitiveness

STEPHEN EZELL | JULY 2020

If the United States is serious about maintaining its leadership in biopharmaceuticals, then it's time for policymakers to articulate and embrace a robust sectoral competitiveness strategy.

KEY TAKEAWAYS

- The biopharmaceutical industry makes important contributions to the U.S. economy, including employing over 500,000 workers making 1.4 times the U.S. earnings average.
- The United States leads the world on most indices of R&D investment and innovation. From 2004 to 2018, U.S.-headquartered firms produced almost twice as many new drugs as did firms in Europe, and 3 to 4 times as many as Japan.
- Despite U.S. strengths in biopharmaceutical R&D and innovation, manufacturing has dropped. From 2009 to 2018, real value-added output in pharmaceutical and medicines manufacturing fell by nearly one-third.
- Partly as a consequence, the U.S. trade balance in pharmaceuticals has grown from a deficit of $16 billion in 2010 to a deficit of $77 billion in 2019.
- Calls for reshoring more biopharmaceutical manufacturing should distinguish between mature manufacturing processes and those still evolving, as in continuous process biomanufacturing, where U.S.-based production can enjoy unique strengths.
- America must continually bolster its biopharmaceutical leadership position, especially as China implements ever-more aggressive policies to improve their life-sciences competitiveness, not only in production but also in innovation.
- To support the sector, policymakers should focus on: 1) maintaining strengths, including in pricing, tech transfer, and intellectual property; 2) spurring domestic innovation; 3) spurring increased domestic production; and 4) combatting foreign mercantilism.

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Thank You!

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