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SPARKING ECONOMIC GROWTH

How Fundamental Research Drives Economic Growth and Innovation

Analysis Conducted for
The Science Coalition
by FTI Consulting

THE SCIENCE COALITION

CONTENTS

OVERVIEW

Fundamental research is where innovation begins. It is the foundation of all scientific progress — the pursuit of original, first-level knowledge that catalyzes advancements in science, technology, medicine, energy, and national security. For decades, federal agencies have led the way in fundamental research, awarding grants to innovative projects at colleges and universities, where much of this research takes place. Through this competitive process, federal dollars have supported — and continue to support — advances across industries, from chemical manufacturing to telecommunications to behavioral sciences and myriad others.

To understand the economic impact of fundamental research investment, FTI Consulting (FTI) analyzed the research expenditures of members of The Science Coalition (TSC), a non-profit, nonpartisan organization of more than 50 of the nation's leading public and private research institutions between 2015 and 2019. FTI also examined the impact of select "spinoff" companies rooted in the federally funded research conducted at TSC universities. FTI found that as a result of the long-term federal investment in fundamental research, new innovations, businesses, and jobs are created, all of which transform daily life for millions of people in communities across the country.

Spinoff companies have vast supply chains that have resulted in economic footprints beyond the states they are based in. The surveyed companies contributed more than $1.3 billion toward the U.S. Gross Domestic Product (GDP) between 2015 and 2019 and supported nearly 100,000 jobs across the nation. An important note: this work represents just a fraction of the economic benefits created through federal funding for fundamental research. What begins as a broad research hypothesis often results in a discovery that underpins innovative new industries — ones that create jobs, improve daily life, and promote the workforce of the future. The return on investment in fundamental research has also been made abundantly clear over the last year as the world grappled with the COVID-19 pandemic. Thanks to decades of work conducted by universities and their federal research agency partners, innovations like vaccines, treatments, and emergency medical equipment were created at a breakneck pace. As the U.S. economy recovers from subsequent economic fallout of the pandemic, fundamental scientific research will continue to play a pivotal role, sparking economic growth in countless ways and at every level of the supply chain.

Much of today's fundamental scientific research would be impossible without strong federal investment. And if we have learned anything over the past year, it is that good things take time. Now is the time to redouble our commitment to federal investment in fundamental research to ensure the American scientific enterprise, and the workforce that serves as its backbone, remains strong, capable, and ready to address the nation's most pressing issues.

KEY FINDINGS

- The 53 companies highlighted in this report **contributed more than $700 million** to the U.S. Gross Domestic Product (GDP) between 2015 and 2019.
- These companies **attracted more than $1.75 billion in research grants** from both public and private sources.
- Research grants enabled these companies to **support 9,300 direct jobs nationally**, contribute $729 million to the U.S. GDP, and pay $115.3 million in federal taxes and $42.9 million in state taxes, all while conducting innovative research and developing new products.
    - **The 49,240 operations jobs and 48,080 research jobs** created or supported by the research expenditures **translates to $1.3 billion in federal tax revenues and $430 million in states tax revenues.**

Research grants enabled these companies to support 9,300 direct jobs nationally, contribute $729 million to the U.S. GDP, and pay $115.3 million in federal taxes and $42.9 million in state taxes, all while conducting innovative research and developing new products.

- The companies are based across the country and vary in size, operating with as few as one to as many as 252 direct employees.
- **The 53 companies in the sample were based in 12 states but provided direct and indirect employment throughout all 50 states**. The companies provide opportunities for economic growth and development both in the states where they are based and across the country. They are only a snapshot of the almost incalculable contributions that fundamental research makes to the U.S. economy and society.
- **These companies span industries**, including science, technology, engineering, and math (STEM) fields like advanced manufacturing, as well as industries like education, language, energy, environmental remediation, and more. There is truly no limit to science's ability to solve problems and spur economic growth.
- These companies help to **create and bring to market the next generation** of therapeutics, electronic devices and services, software, analytics, trainings, education, and other professional services.

FUNDAMENTAL RESEARCH: WHERE INNOVATION BEGINS

Fundamental research, also known as basic research, is experimental research that seeks to gain new knowledge and understanding of an existing phenomenon. The primary purpose of fundamental research is to answer questions about how certain phenomena exist or function; it is the foundation of applied research and all scientific and technological inquiry. Fundamental research tends to be theoretical, especially compared to applied research, which is conducted at a later stage to achieve a specific and narrower objective.[1]

The importance of fundamental research cannot be overstated; it has led to discoveries with practical and ground-breaking applications in every field and sector. Given the long-term nature of fundamental research, much of it relies on federal investment through agencies like the National Science Foundation (NSF). Federal funding in fundamental research has also resulted in the founding of leading companies like Google and Pfizer.[2]

Thanks to federal funding, TSC member institutions have conducted fundamental research that led to the creation of new companies, and in turn, new innovations nationwide. Many of the innovations these companies produced, from therapies that treat drug-resistant bacteria to technology that can detect and mitigate food waste, originated from fundamental research conducted with the support of federal grants. And while many are still in the beginning stages of development, the innovations hold immense promise for transforming society as we know it. **Take Bionet Sonar, a Northeastern University spinoff company, which was awarded funding by the Department of Defense (DOD) and National Science Foundation (NSF).** The company is developing an alternative to traditional medical implants which use microwave radio frequency. Not only are these radio frequencies expensive, but they are also capable of being hacked and have been linked to cancer. Bionet Sonar's implants are crafted to have lower absorption in tissues and likely last longer than traditional implants.

Bionet Sonar's innovative technology rooted in federal investment is not unique. SensIT Venture's agricultural prototype sensors came about through research conducted at the University of California, Davis that was supported by funding from NSF. These sensors detect gases that can be early indicators of crop rot, and this technology could help preserve crops around the world — up to 50 percent of which are lost to crop diseases, pests, or issues post-harvest.[3]

"If not for the federal funding, which lead to the creation of the core technology, Bionet would not exist."

(TSC Institution: Northeastern University; Federal Agency Funding: Department of Defense and National Science Foundation)

bionet

Additionally, by leveraging funding awarded to the University of Rochester by NIH and the National Institute of Mental Health (NIMH), Community Forensic Interventions provides trainings for law enforcement and mental health professionals to reduce psychiatric hospitalizations, jail time, convictions, and violent incidents among justice-involved adults with mental illness. This work is critical, considering adults with mental illnesses make up more than 17 percent of those arrested each year and about half of all incarcerated individuals in the U.S. have a history or current indicator of a mental health problem.[4,5,6,7]

Furthermore, Orchard Therapeutics is advancing medicine by providing for the ability to treat rare, inherited disorders with nonexistent or complicated current treatments. Orchard Therapeutics, which was created out of federally funded research conducted at the University of California, Los Angeles, focuses on therapeutic areas such as primary immune deficiencies, neurometabolic disorders, and hemoglobinopathies. Orchard's autologous ex vivo gene therapy program utilizes a patient's own blood stem cells (autologous) and improves them using gene therapy outside of the body (ex vivo). The self-renewing blood stem cells that are repaired offer a permanent solution to these diseases and are an improvement over the standard of care: high-risk bone marrow transplant.

Finally, Exyn Technologies, which was established based on research that was performed at the University of Pennsylvania and funded by NSF, automates data collection in difficult and dangerous environments with autonomous flight and aerial robotics. The robots operate without needing GPS, prior maps, or a pilot at all, allowing operators to stay out of dangerous or inaccessible areas and still get unparalleled data capture. Exyn often supplies these robots to help the mining industry navigate underground mines.

"Federal funding allowed proof-of-concept work to be performed at UC Davis. Specifically, the company identified a druggable pathway, identified a small-molecule inhibitor of the pathway, and developed a potential formulation. In-vitro and in-vivo data led to intellectual property including two use patents and one pending formulations patent being licensed."

(TSC Institution: University of California, Davis; Federal Agency Funding: National Institutes of Health)

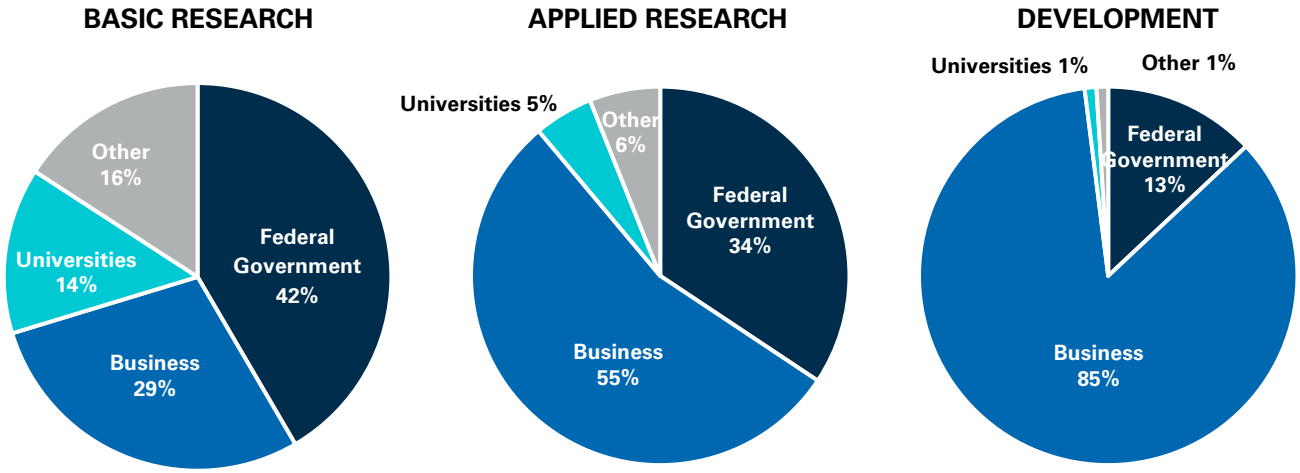
Tesio Pharmaceuticals

Federal Investment in Fundamental Research is the Bedrock of Economic Growth

The U.S. government continues to be a leader in fundamental research funding, investing billions of dollars annually into R&D. Specifically, the federal government's contribution makes up 42 percent of total funding for U.S. fundamental research (Figure 1).

Federal investment in university research is the linchpin that ensures fundamental research continues year after year. Overall, research universities perform more than half of U.S. fundamental research, making them the second-largest contributors to U.S. R&D.[8] **The majority (64 percent) of university research is fundamental, compared to applied (26 percent), which is more typically funded by the private sector.**[9]

Figure 1. Composition of U.S. Basic Research, Applied Research, and Development by Funding Sector, 2018



Source: CRS analysis of National Science Foundation, *National Patterns of R&D Resources: 2017-18 Data Update*, NSF 20-307, Tables 6-9, January 8, 2020.
Notes: Components may not add due to rounding. Data are preliminary and may be revised.

In 2020, the federal government was the single largest funder of university research, contributing more than half (52 percent) of all university R&D funding that year.[10] In fact, between 2000 and 2017, the federal government distributed the majority of its R&D funds to institutions of higher education, followed by businesses and nonprofits.[11]

Beyond its capacity to enable life-improving discovery across myriad disciplines, this federal investment in research has resulted in short- and long-term economic benefits by contributing to hundreds of thousands of jobs each year, which in turn generate billions of dollars in wages, taxes, and GDP growth.

In 2018, the federal government's **$131 billion investment in R&D resulted in 445,800 direct American jobs.**[12] Jobs funded through federal R&D tend to pay significantly higher wages compared to average pay in the U.S. In 2018, compensation for the average direct job funded by federal R&D was $114,000, 83 percent higher than the U.S. average.[13,14] Overall, federal investment funded $50.9 billion in wages, salaries, fringe benefits, and proprietors' income for employees connected to its funding efforts. Research undeniably contributes to Americans' individual and collective economic advancement.

Federal R&D funding not only benefits employees directly impacted by these investments, but also local and national economies. **The aforementioned $131 billion investment in R&D directly generated $70.6 billion in GDP and $13.0 billion in tax payments to federal, state, and local**
Overall, in 2018, federal R&D funding directly and indirectly supported:

- **~ 1.6 Million U.S. Jobs**
- **$126 Billion in Labor**
- **$197 Billion in Added Economic Value**
- **$39 Billion in Federal and State Tax Revenue.**[15]

Federal R&D can also result in long-term financial benefits. A 2016 study of member countries from the Organisation for Economic Co-operation and Development (OECD) **found evidence that countries could experience higher increases in economic and welfare-maximizing benefits if they were willing to invest more in fundamental research today.**[16]

FUNDAMENTAL RESEARCH AT TSC UNIVERSITIES DRIVES ECONOMIC GROWTH ACROSS THE SUPPLY CHAIN

While fundamental research has served as the backbone of some of the most important innovations, the importance of this research is often underestimated. To highlight the impacts of fundamental research funding on U.S. economic growth, FTI analyzed a sample of spinoff companies, many of which are grounded in federal research funding, and found the companies are connecting communities, creating jobs, supporting businesses, and driving the U.S. economy.

The purpose of FTI's analysis was to fill a gap in our understanding of the economic benefits of fundamental research and shed light on its myriad benefits. FTI analyzed data from 2015 through 2019 on 53 companies that were created as a result of TSC member institutions' research and development expenditures.

53 companies in our sample support nearly 100,000 jobs, attract billions of dollars in research grants, and contribute more than $1.3 billion in U.S. GDP across all 50 states, despite being based in only 12 states.

In addition, FTI considered the number of companies created by TSC research expenditures in the past five years. Throughout this report we highlight the companies' innovations and their financial impact on surrounding communities and on the wider economy.

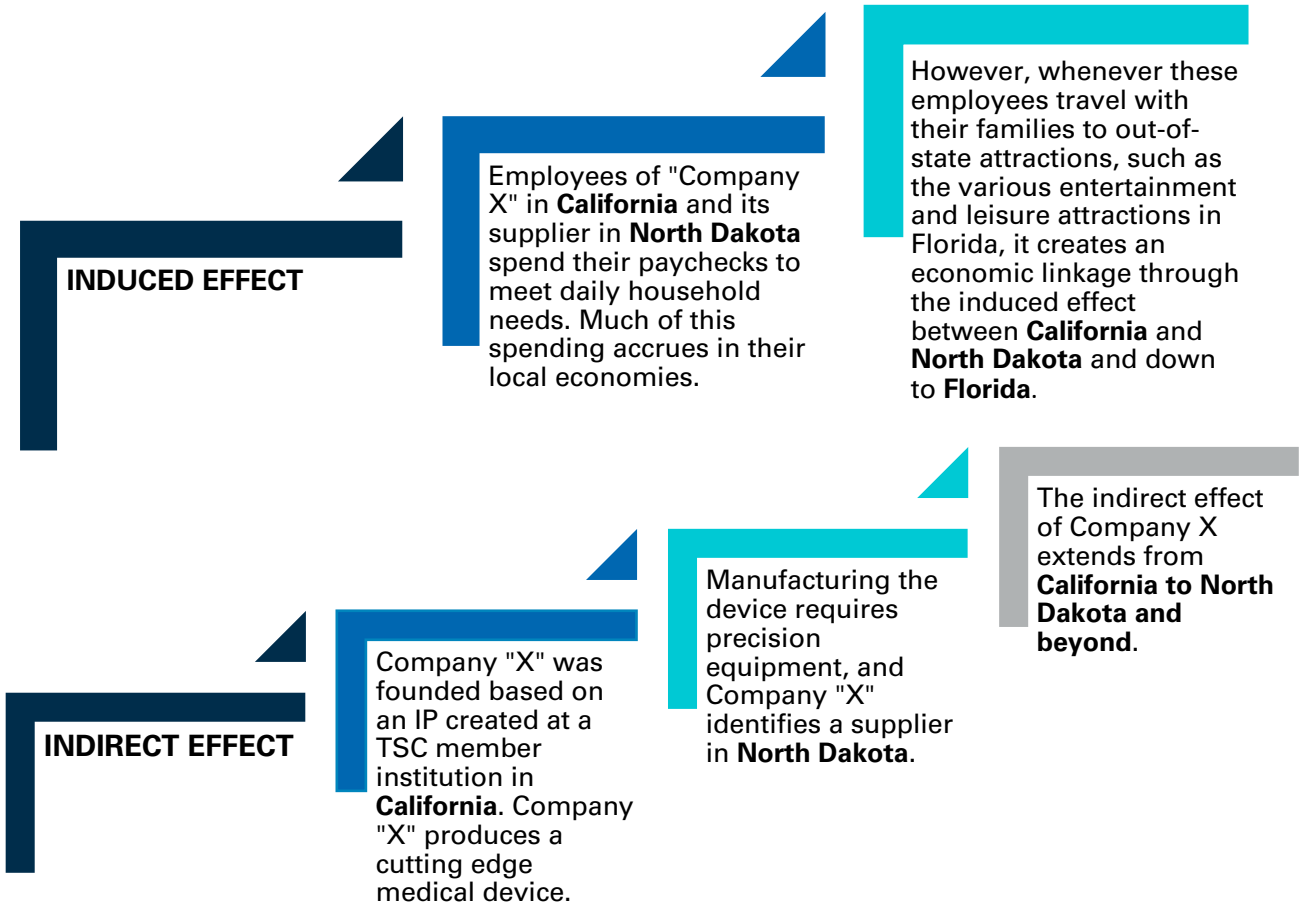
TSC universities' research expenditures have led to the creation of dozens of new companies nationwide. The analysis revealed that, together, the 53 companies in our sample support nearly 100,000 jobs, attract billions of dollars in research grants, and contribute more than $1.3 billion in U.S. GDP across all 50 states, despite being based in only 12 states.

The companies operate around the country and range in size and scope. **Wisconsin-based Marquette Energy Analytics**, a spinoff of research conducted at Marquette University, employs a handful of skilled professionals to perform energy demand modeling, forecasting, and analytics for U.S. facilities. In California, Orchard Therapeutics, established through research born at the University of California, Los Angeles, has over 250 employees and developed the first autologous ex vivo gene therapy program to be approved by the European Medicines Agency (EMA).

Each of these companies generates additional economic output through their supply chains — including vendors of equipment, materials, components, and expertise to operate — that stretch far beyond the state in which they operate, contributing additional jobs, tax revenue, and economic activity. In short: **federal investment in research benefits everyone, regardless of where the grant was awarded**.

These companies fuel the economy through both "indirect effects," defined as the economic impact a company has on its suppliers through their established supply chains, as well as "induced effect," or the effect that a company and its supply chain's employees have on the economy when they spend their paychecks (Figure 2).

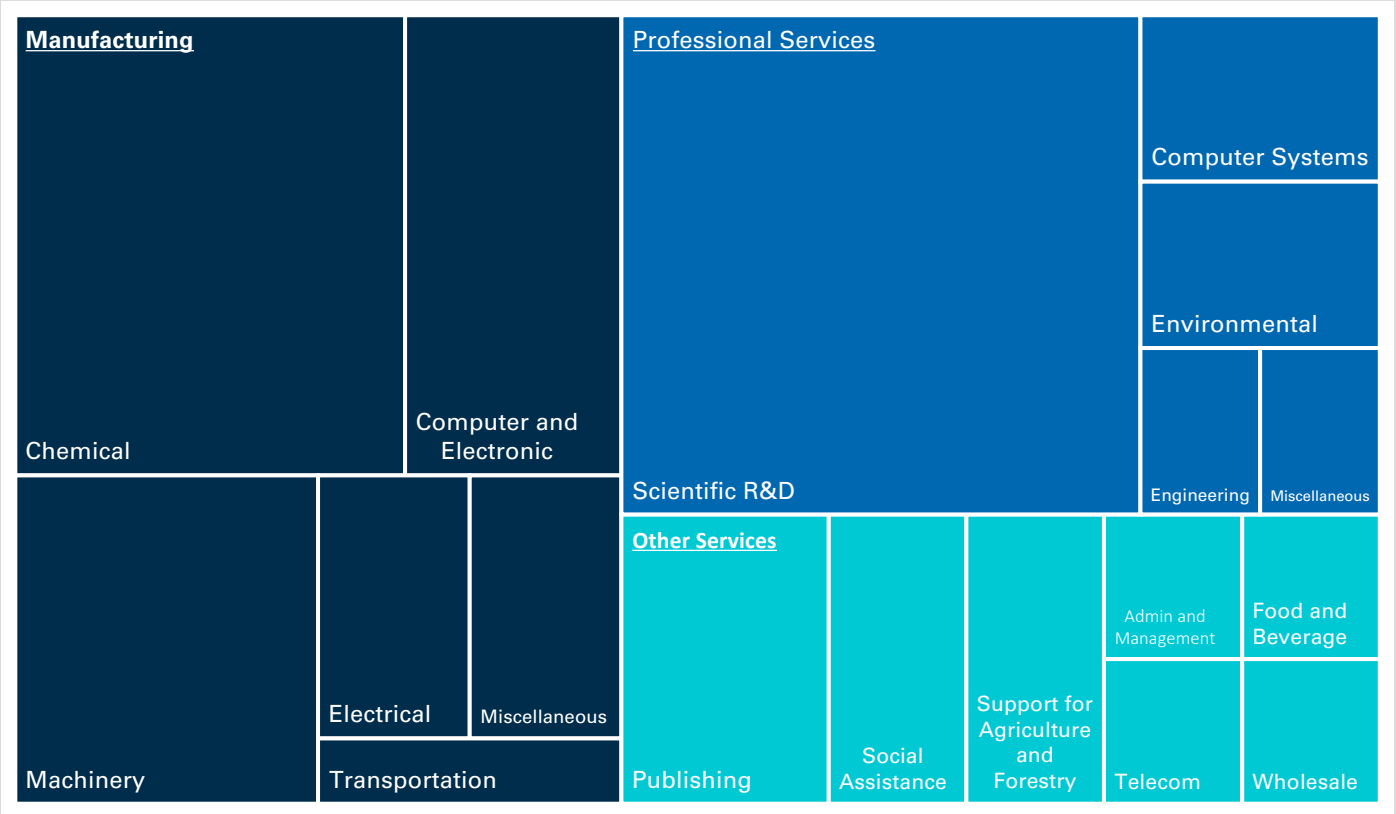
Figure 2: Example Supply Chain



The economic benefits of the fundamental research we studied also span industries. Of the 53 companies examined, the majority operate in STEM sectors. Many are in the professional services sector, including companies like **Deepbits Technology Inc., grounded in research performed by the University of California, Riverside with funding from NSF, which provides security analytics tools used to build cybersecurity solutions. Deepbits Technology developed "Dr. Binary," a platform that identifies vulnerabilities and malware.** This platform is expanding the cybersecurity market by helping to reduce the amount of R&D expenditure necessary for other companies to enter this space. As a result, cybersecurity spending could become more affordable for corporations and governments alike.

Many other companies we examined are in advanced manufacturing (especially chemicals and more specifically pharmaceutical products), including LighTopTech, a company grounded in NIH funding granted to the University of Rochester, where researchers develop imaging technology that produces two- and three-dimensional images of many materials including organic tissue, polymers, and glass. LighTopTech's imaging solutions allow medical professionals to rapidly and noninvasively image subcellular structures beneath the surface of the skin or within the human eye, and provides material imaging for manufacturers to monitor quality of the manufacturing process, improving quality and yield. This technology has improved non-invasive and non-destructive imaging for medical applications, such as cut-free biopsies for skin cancer imaging and imaging of the corneal layers of the eye to detect and monitor nerve loss that results from diabetes. It also supports manufacturing of polymers and glass to obtain images beneath the surface to monitor the quality of the manufacturing process. (Figure 3).

Figure 3: Distribution of Sampled Companies by Economic Sector



Spinoff Companies Have Multi-Billion Dollar Impact on U.S. Economy

Every sampled spinoff company has driven innovation, manufacturing, and research that benefits the economy. Beyond that benefit, all 53 companies had further explicit economic impacts in the states where they operate, contributing a combined $42.9 million in state taxes. **The companies also support 9,300 direct jobs in all 50 states, as well as $729.0 million in U.S. GDP and $115.3 million in federal taxes.**[17]

That return on investment is surely understated, given the 53 companies included in the analysis are just a small subset of the total number of companies created by federally funded university research over time.

University Research Expenditures Allow Innovation to Flourish

From 2015 through 2019, U.S. colleges and universities performed about $76.8 billion worth of R&D. Over those same five years, TSC member institutions averaged $33.1 billion in R&D expenditures, which accounted for 43 percent of all university research expenditures in the U.S. during that time.

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For many of these companies, their innovative products would not exist today without the research expenditures of academic institutions and the related research grants from the federal government and private sector. Over the five-year period, these companies attracted over $1.75 billion in research grants from both public and private sources.

Federal Agencies Award Funding to Bring Innovative Ideas to Life

Federal agencies award millions in research grants that are diversified across economic sectors, from health care to energy. Funding agencies for new innovations created by spinoff companies include: NIH, DOD, the National Aeronautics and Space Administration (NASA), the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and more.

For instance, research funded by **the Defense Advanced Research Projects Agency (DARPA) and conducted at Massachusetts Institute of Technology (MIT), led to the invention of the first processor to communicate using light, which was the basis for Ayar Labs.** The company negotiated a licensed portfolio of patents from MIT that were developed from that federally funded research. This innovation is revolutionizing chip technology and data transfer by allowing data to move between chips using light instead of electricity transmitted through copper wires. As a result, this technology is expanding the use and capabilities of technologies such as artificial intelligence, cloud computing, and 5G.

Oscine Therapeutics is the culmination of more than 15 years of research at University of Rochester Medical Center (URMC), which was performed through funding provided by NIH. With that funding, Steve Goldman, M.D., Ph.D, professor of Neurology and Neuroscience and co-director of the URMC Center for Translational Neuromedicine, performed research on special support cells in the brain called glial cells, which can disappear or malfunction, resulting in neurological diseases like multiple sclerosis, Huntington's, and neuropsychiatric disorders. Dr. Goldman's lab developed methods to replace the sick glial cells with healthy ones, leading to the creation of Oscine Therapeutics, which developed cell-based therapies for these disorders. Oscine Therapeutics' cell-based therapies are now advancing towards clinical trials in humans with the potential to transform the lives of patients around the globe.

"DARPA provided the funding for the foundational research for our company. Its $20M resulted in the world's first processor to communicate using light, and that demonstration paved the way for Ayar Labs to form as a company and bring this breakthrough to the market with our high-performance, low-power optical I/O chiplets."

(TSC Institution: Massachusetts Institute of Technology; Federal Agency Funding: Defense Advanced Research Projects Agency)

AyarLabs

Fundamental Research Catalyzes Economic Activity

Spinoff Companies Support Thousands of Jobs

Federally funded research increases innovation among local private firms, accelerates the creation of new startups, and attracts private R&D investments.[18,19] Companies formed by TSC members' research activity create new jobs for thousands of Americans across the country. In total, the 53 surveyed companies provide 786 direct jobs (Table 1).

Table 1: Employment and Economic Impact ($ millions) of Companies Included in the Sample

Company	TSC University	Federal Agency Sponsor	Direct Jobs	Total Jobs (Operations)	Total Jobs (Research)	Total Jobs Impact
Orchard Therapeutics	**University of California, Los Angeles**	**National Institutes of Health**	252	2,340	2,416	4,756
Synlogic, Inc.	**Massachusetts Institute of Technology**	**National Institutes of Health**	69	488	441	930
Locus Biosciences	**North Carolina State University**	**National Institutes of Health, National Science Foundation, United States Department of Agriculture**	39	208	439	647
Ayar Labs	**Massachusetts Institute of Technology**	**Defense Advanced Research Projects Agency**	70	320	366	686
Mammoth Biosciences, Inc.	**University of California, Berkeley**	**National Institutes of Health, National Science Foundation**	36	91	361	452
Cytovale	**University of California, Los Angeles**	**National Science Foundation, U.S. Office of Naval Research, Defense Advanced Research Projects Agency, National Institutes of Health**	15	56	115	171
Exyn Technologies	**University of Pennsylvania**	**No response provided.**	49	69	103	173
InVivo Biosystems	**University of Oregon**	**National Institutes of Health**	46	172	72	244
WiBotic	**University of Washington**	**National Science Foundation, National Institutes of Health**	15	80	52	132
Jeeva Wireless	**University of Washington**	**National Science Foundation**	13	63	52	115
Instrumems, Inc.	**Princeton University**	**National Science Foundation, U.S. Office of Naval Research**	5	20	21	40
Bionet Sonar, Inc.	**Northeastern University**	**Department of Defense, National Science Foundation**	8	31	17	49
South 8 Technologies	**University of California, San Diego**	**National Science Foundation, National Aeronautics and Space Administration, Department of Education**	5	16	17	33
iota Motion	**University of Iowa**	**No response provided.**	5	19	15	33
Drone Amplified	**University of Nebraska**	**National Science Foundation**	7	15	14	29
LighTopTech	**University of Rochester**	**National Institutes of Health, National Eye Institute**	4	6	8	14

Cellec Technologies, Inc.	**Rochester Institute of Technology**	**No response provided.**	7	23	8	31
OmniLife	**University of Iowa**	**No response provided.**	6	10	7	17
FarmSense	**University of California, Riverside**	**National Science Foundation**	6	22	6	29
AirLift Environmental, LLC	**University of Nebraska**	**Environmental Protection Agency**	2	7	6	14
risQ, Inc.	**Northeastern University**	**National Science Foundation**	12	45	6	51
ViQi	**University of California, Santa Barbara**	**National Science Foundation**	10	25	6	31
Deepbits Technology, Inc.	**University of California, Riverside**	**National Science Foundation, U.S. Office of Naval Research**	3	4	5	9
Kalion, Inc.	**Massachusetts Institute of Technology**	**U.S. Office of Naval Research, National Science Foundation**	5	19	4	23
Manifold Robotics	**New York University**	**National Science Foundation**	3	17	4	21
Cognivive, Inc.	**University of California, Davis**	**National Institutes of Health**	5	19	4	22
KLAR Scientific	**Washington State University**	**National Science Foundation**	5	22	3	24
RAMDO Solutions	**University of Iowa**	**No response provided.**	2	7	3	9
Firefly Photonics	**University of Iowa**	**No response provided.**	3	11	3	14
Sunthetics	**New York University**	**National Science Foundation**	1	4	2	6
Pani Clean	**University of Iowa**	**No response provided.**	1	4	2	6
Conidiotec, LLC	**The Pennsylvania State University**	**United States Department of Agriculture**	6	71	2	73
Rapid Radicals Technology, LLC	**Marquette University**	**National Science Foundation, Water and Equipment Policy Industry-University Cooperative Research Center**	1	3	2	5
Synder Bio	**University of Iowa**	**No response provided.**	2	9	2	11
Spirovant Sciences	**University of Iowa**	**No response provided.**	1	4	1	5
Apsidal	**University of California, Riverside**	**National Aeronautics and Space Administration**	4	13	1	14
Senseion	**University of Iowa**	**No response provided.**	1	2	1	3

Tesio Pharmaceuticals, Inc.	**University of California, Davis**	**National Institutes of Health**	8	30	1	31
Optimeos Life Sciences	**Princeton University**	**National Institutes of Health, National Science Foundation**	4	21	1	22
OscillaVent	**University of Iowa**	**No response provided.**	3	15	1	15
Theion Agriculture, LLC	**University of Iowa**	**No response provided.**	1	2	1	3
SensIT Ventures, Inc.	**University of California, Davis**	**National Science Foundation**	3	11	0	11
Estrigenix Therapeutics, Inc.	**Marquette University**	**National Institutes of Health, General Medical Sciences**	1	2	0	2
Marquette Energy Analytics, LLC	**Marquette University**	**No federal funding.**	11	90	0	90
Suprasensor Technologies, LLC	**University of Oregon**	**National Science Foundation**	10	102	0	102
ParaTools, Inc.	**University of Oregon**	**ParaTools received several contracts from the federal government but no federal agency provided funding to establish the company.**	8	30	0	30
Autism Navigator	**Florida State University**	**National Institutes of Health**	6	22	0	22
Community Forensic Interventions	**University of Rochester**	**National Institutes of Health, National Institute of Mental Health**	2	19	0	19
Caballeta Bio	**University of Pennsylvania**	**National Institutes of Health**	1	5	0	5
Exyn Technologies	**University of Pennsylvania**	**National Science Foundation, Army Research Lab, U.S. Office of Naval Research, Army Research Office, Defense Advanced Research Projects Agency**	1	5	0	5
Linnaeus Therapeutics	**University of Pennsylvania**	**National Institutes of Health**	1	1	0	1
Oscine Therapeutics	**University of Rochester**	**National Institute of Health, National Institute of Neurological Disorders and Stroke**	1	4	0	4
Tmunity Therapeutics, Inc.	**University of Pennsylvania**	**National Institutes of Health**	1	4	0	4
TOTAL			**786**	**4,698**	**4,588**	**9,287**

"The cooperation between companies, universities, and the federal government helps create and support small businesses in the U.S. that have a global impact."

(TSC Institution: University of Oregon)

ParaTools

When the companies' supply chains are taken into account, research activity at TSC member institutions supported the creation of a total of 49,240 operations jobs and 48,080 research jobs. These jobs include direct employment from the companies themselves, their supply chains, or their induced effects (the effect a company and its supply chain's employees have on the economy when they spend their paychecks as consumers).

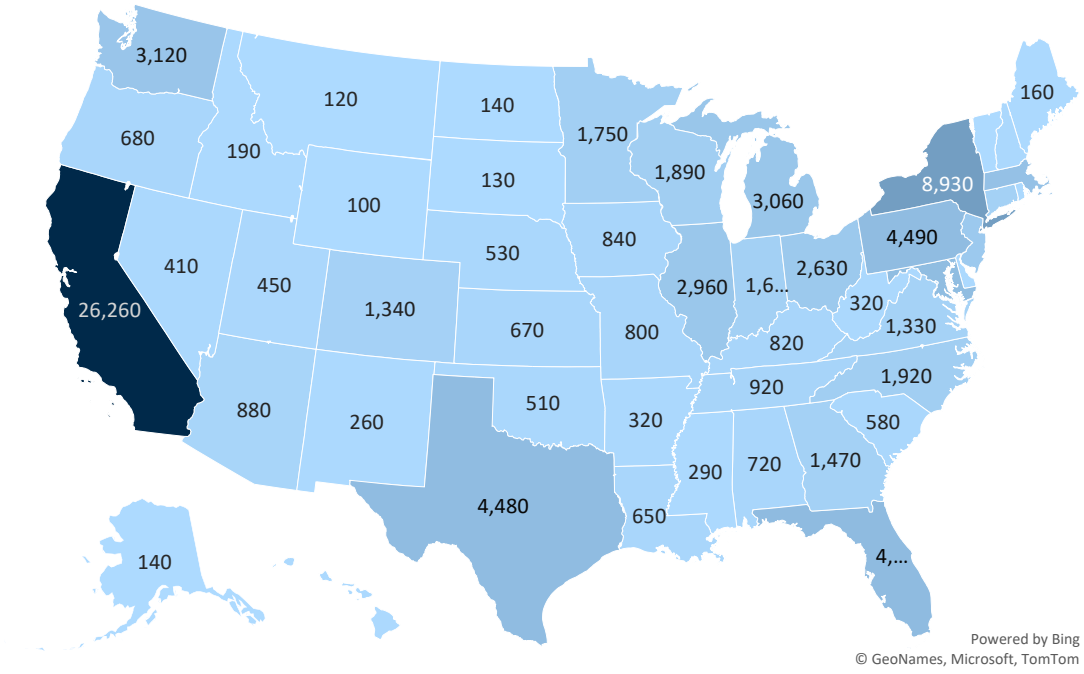
For instance, between 2015 and 2019, Conidiotec directly employed six people. The company, which was grounded in research performed at the Pennsylvania State University and funded by the USDA, developed a formulation for indoor pest control focused on eliminating and preventing bed bugs, that has an active ingredient that remains effective for 90 days. The product, which is the first of its kind, supported more than 70 jobs through the company's supply chain and induced effects.

During that same time, Orchard Therapeutics, a spinoff company that resulted from research expenditures at the University of California, Los Angeles that developed the first autologous ex vivo gene therapy program to be approved by the European Medicines Agency (EMA), directly employed 252 individuals.

Orchard Therapeutics' autologous ex vivo gene therapy program utilizes a patient's own blood stem cells (autologous) and improves them using gene therapy outside of the body (ex vivo). The self-renewing blood stem cells that are repaired offer a permanent solution to some diseases and are an improvement over the standard of care: high-risk bone marrow transplants.

Orchard Therapeutics has partnerships with universities in California and Massachusetts and engages other companies for manufacturing and delivery of its therapies. Through its vast supply chain, **Orchard Therapeutics' total jobs impact jumped from 252 to 4,756**. Across the U.S., each of the 53 spinoff companies resulted in the employment of between 80 and 26,260 people in all 50 states (Figure 4).

Figure 4: Employment Supported by Companies Created by Federally Funded Research at TSC Member Institutions



State	Result
CT	1,470
DE	180
DC	360
FL	4,630
HI	230
IN	1,610
MD	4,420
MA	3,720
NH	410
NJ	2,590
RI	340
VT	80

Spinoff Companies Contribute $1.3 Billion to U.S. GDP

By studying the overall impact to the U.S. GDP, FTI's analysis found that the reviewed spinoff companies from TSC institutions contributed hundreds of millions of dollars to U.S. GDP. The 53 companies supported $729 million in U.S. GDP, which breaks down to individual companies contributing between about $100,000 and $284.5 million (Table 2).

The 49,240 operations jobs and 48,080 research jobs created or supported by the research expenditures translates to $1.3 billion in federal tax revenues, and $430 million in states tax revenues.

Mammoth Biosciences is one of the top individual contributors to U.S. GDP at $54.5 million. The company spurred from federal research funding granted to University of California, Berkeley by Howard Hughes Medical Institute, NSF, and NIH. Mammoth's novel functionality, CRISPR based diagnostics, has transformed the field of molecular testing by enabling the development of tests that have molecular level accuracy while also having the potential to be in a rapid and accessible at-home format.

Mammoth has also developed a new family of nano-sized CRISPR proteins that can unlock new ways of developing and delivering in-vivo therapies. Their diagnostic tools have huge implications for screening row crops and manufacturing facilities for contaminants.

The companies studied have also contributed to state and national economies by providing jobs and contributing a significant amount in state and federal taxes. The 49,240 operations jobs and 48,080 research jobs created or supported by the research expenditures translates to $1.3 billion in federal tax revenues, and $430 million in states tax revenues (Table 2). Considered on an individual basis, the federal taxes companies paid ranged from $42.9 million to less than $100,000 per company. Similarly, the state taxes individual companies paid ranged from $17.9 million to less than $100,000 (Table 2).

"Federal funding was absolutely essential to launching Jeeva. Several years of fundamental research, which led to numerous awards and patents, created the fundamental technology. Then further grants and contracts from the government have allowed the company to take the technology further, turning it in to a real business, creating new jobs."

(TSC Institution: University of Washington; Federal Agency Funding: National Science Foundation)

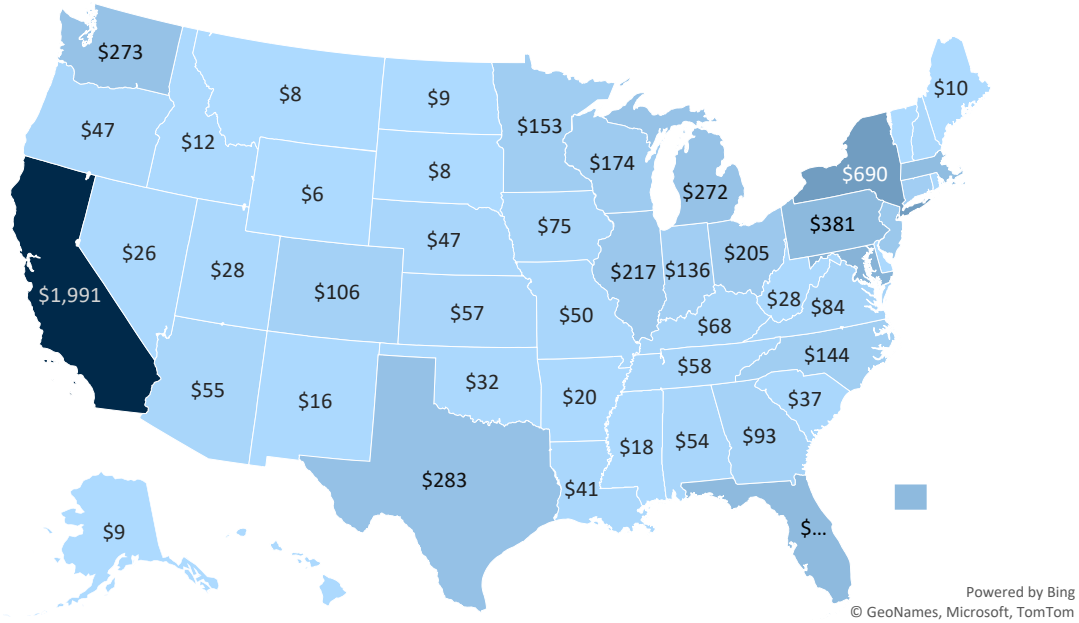
Table 2: Employment and Economic Impact ($ millions) of Companies Included in the Sample

Company	TSC University	Direct Jobs	Total Fed Taxes	Total State Taxes	Total GDP Impact
Orchard Therapeutics	**University of California, Los Angeles**	252	$42.9	$17.9	$284.5
Synlogic, Inc.	**Massachusetts Institute of Technology**	69	$11.0	$2.9	$54.9
Locus Biosciences	**North Carolina State**	39	$13.2	$4.5	$88.8
Ayar Labs	**Massachusetts Institute of Technology**	70	$13.0	$5.4	$86.1
Mammoth Biosciences, Inc.	**University of California Berkeley**	36	$8.2	$3.4	$54.5
Cytovale	**University of California, Los Angeles**	15	$3.3	$1.4	$22.0
Exyn Technologies	**University of Pennsylvania**	49	$2.6	$0.8	$14.7
InVivo Biosystems	**University of Oregon**	46	$2.2	$0.8	$15.6
WiBotic	**University of Washington**	15	$2.6	$0.8	$15.5
Jeeva Wireless	**University of Washington**	13	$2.5	$0.8	$15.4
Instrumems, Inc.	**Princeton University**	5	$0.4	$0.2	$2.7
Bionet Sonar, Inc.	**Northeastern University**	8	$1.2	$0.3	$5.9
South 8 Technologies	**University of California San Diego**	5	$0.5	$0.2	$3.4
iota Motion	**University of Iowa**	5	$1.0	$0.2	$3.9
Drone Amplified	**University of Nebraska**	7	$0.8	$0.2	$4.3
LighTopTech	**University of Rochester**	4	$0.2	$0.1	$1.3
Cellec Technologies, Inc.	**Rochester Institute of Technology**	7	$0.3	$0.1	$1.6
OmniLife	**University of Iowa**	6	$0.4	$0.1	$1.5
FarmSense	**University of California, Riverside**	6	$0.1	$0.1	$0.8
AirLift Environmental, LLC	**University of Nebraska**	2	$0.2	$0.0	$0.8
risQ, Inc.	**Northeastern University**	12	$0.5	$0.1	$2.5
ViQi	**University of California, Santa Barbara**	10	$0.4	$0.1	$2.4
Deepbits Technology, Inc.	**University of California, Riverside**	3	$0.2	$0.1	$1.2
Kalion, Inc.	**Massachusetts Institute of Technology**	5	$0.6	$0.2	$3.1
Manifold Robotics	**New York University**	3	$0.6	$0.2	$3.5
Cognivive, Inc.	**University of California, Davis**	5	$0.5	$0.2	$3.3
KLAR Scientific	**Washington State University**	5	$0.5	$0.1	$2.9
RAMDO Solutions	**University of Iowa**	2	$0.2	$0.1	$1.3
Firefly Photonics	**University of Iowa**	3	$0.2	$0.1	$1.4
Sunthetics	**New York University**	1	$0.1	$0.0	$0.6

Pani Clean	**University of Iowa**	1	$0.1	$0.0	$0.5
Conidiotec, LLC	**The Pennsylvania State University**	6	$0.3	$0.1	$1.9
Rapid Radicals Technology, LLC	**Marquette University**	1	$0.1	$0.0	$0.5
Synder Bio	**University of Iowa**	2	$0.4	$0.1	$1.4
Spirovant Sciences	**University of Iowa**	1	$0.1	$0.0	$0.6
Apsidal	**University of California, Riverside**	4	$0.1	$0.0	$0.4
Senseion	**University of Iowa**	1	$0.1	$0.0	$0.2
Tesio Pharmaceuticals, Inc.	**University of California, Davis**	8	$0.7	$0.3	$4.7
Optimeos Life Sciences	**Princeton University**	4	$0.8	$0.2	$3.6
OscillaVent	**University of Iowa**	3	$0.2	$0.1	$1.3
Theion Agriculture, LLC	**University of Iowa**	1	$0.0	$0.0	$0.2
SensIT Ventures, Inc.	**University of California, Davis**	3	$0.1	$0.0	$0.8
Estrigenix Therapeutics, Inc.	**Marquette University**	1	$0.0	$0.0	$0.0
Marquette Energy Analytics, LLC	**Marquette University**	11	$0.2	$0.1	$1.4
Suprasensor Technologies, LLC	**University of Oregon**	10	$0.1	$0.0	$0.8
ParaTools, Inc.	**University of Oregon**	8	$0.6	$0.1	$3.0
Autism Navigator	**Florida State University**	6	$0.4	$0.1	$2.1
Community Forensic Interventions	**University of Rochester**	2	$0.5	$0.1	$2.9
Caballeta Bio	**University of Pennsylvania**	1	$0.1	$0.0	$0.8
Exyn Technologies	**University of Pennsylvania**	1	$0.1	$0.0	$0.8
Linnaeus Therapeutics	**University of Pennsylvania**	1	$0.0	$0.0	$0.1
Oscine Therapeutics	**University of Rochester**	1	$0.1	$0.0	$0.4
Tmun ity Therapeutics, Inc.	**University of Pennsylvania**	1	$0.1	$0.0	$0.4
TOTAL		786	$115.3	$42.9	$729.0

The companies created through TSC research activity also **contributed between $1.9 million and $5 million to GDP in all 50 states** (Figure 5). TSC member institutions also contributed $7.6 billion in U.S. GDP, with individual universities contributing between $1 million and $594 million (Table 3).

Figure 5: GDP Contribution of Companies Created by TSC Research Activity ($ millions)



State	Result
CT	$135
DE	$11
DC	$23
FL	$364
HI	$15
MD	$136
MA	$445
NH	$336
NJ	$39
RI	$208
VT	$34

Table 3: Research Expenditures and Economic Impact ($ millions) of TSC Member Institutions

University	Total Jobs Impact	Total GDP Impact
Johns Hopkins University	7,572	$594.4
University of Michigan	4,476	$351.4
University of California, San Francisco	4,128	$324.1
University of Washington	3,908	$306.8
University of Pennsylvania	3,812	$299.2
University of California, San Diego	3,493	$274.2
University of Wisconsin	3,483	$273.4
University of California, Los Angeles	3,387	$265.9
Harvard University	3,309	$259.7
Stanford University	3,269	$256.6
University of Maryland	3,224	$253.1
Massachusetts Institute of Technology	2,824	$221.7
Yale University	2,763	$216.9
University of Minnesota	2,752	$216.0
Columbia University	2,675	$210.0
The Pennsylvania State University	2,546	$199.9
The Ohio State University	2,531	$198.7
New York University	2,441	$191.6
University of Florida	2,426	$190.4
University of California, Berkeley	2,313	$181.5
University of California, Davis	2,231	$175.1
Rutgers University	1,943	$152.5
University of Illinois	1,904	$149.4
Indiana University	1,628	$127.8
North Carolina State University	1,476	$115.8
University of Iowa	1,430	$112.2
University of Colorado Boulder	1,412	$110.9
University of South Florida	1,368	$107.4
University at Buffalo	1,175	$92.2
University of California, Irvine	1,124	$88.3
University of Kentucky	1,096	$86.0
University of Rochester	1,065	$83.6
Washington State University	1,031	$81.0
Princeton University	983	$77.2
University of Kansas	942	$73.9
University of Nebraska	886	$69.5
Florida State University	843	$66.2

Dartmouth College	834	$65.4
Brown University	825	$64.8
Stony Brook University	703	$55.2
University of California, Santa Barbara	688	$54.0
Wayne State University	674	$52.9
University of Notre Dame	627	$49.2
Auburn University	543	$42.6
West Virginia University	530	$41.6
University of California, Riverside	474	$37.2
Northeastern University	438	$34.4
University of California, Santa Cruz	410	$32.2
University of Oregon	293	$23.0
Rochester Institute of Technology	144	$11.3
University of California, Merced	104	$8.2
Marquette University	90	$7.1
Northern Illinois University	63	$5.0
Pace University	14	$1.1
TOTAL	**97,322**	**$7,639.7**

The GDP impacts are greatest in states with the biggest TSC presence, such as California, New York, and the Great Lakes region. Other states impact jobs and GDP through trade between the states, which happens when a spinoff company from a TSC member institution buys from a supplier in a state without TSC representation, or the employees of the spinoff company vacation in a state without a TSC member, such as Nevada. These induced and indirect effects have enabled companies based in 13 states to influence employment and GDP in all 50 states.

Case in Point: How Federal Funding Sparks Innovation and Economic Development

Many of the spinoff companies operating today would not exist without federal research funding that was awarded to TSC institutions as well as the dedication of national research agencies to conduct such research. Below are more examples of these spinoff companies. The companies have developed products and technologies that have revolutionized industries, ensured U.S. competitiveness, and made important contributions to the nation's health, sustainability, and security.

Instrumems (California)

TSC Member Institution: Princeton University, Private

Founding Year: 2016

Founders: Professor Marcus Hultmark and Dr. Gilad Arwatz

Funding Agency: National Science Foundation and Office of Naval Research

About: Instrumems, a California-based company currently headquartered in the heart of Silicon Valley in Los Altos, has created new sensory technology capable of measuring velocity, temperature, and humidity of gaseous and fluid flows. The sensory technology aids efforts to address the COVID-19 pandemic by improving respiratory medical devices like ventilators, respirators, and asthma/COPD inhalers. The technology was originally developed and extensively validated at Princeton University. Instrumems sensors have the potential to replace traditional sensors in current applications as well to enable a broad range of new sensor-driven applications.

"Federal funding is the only way to conduct in-depth fundamental research. Investments in scientific research support the development of technological innovations that start-ups like Instrumems can turn into marketable solutions that can spur economic growth. Federal funding for fundamental research is an investment in scientific progress." — Dr. Marcus Hultmark and Dr. Gilad Arwatz

Autism Navigator (Florida)

TSC Member Institution: Florida State University, Public

Founding Year: 2015

Founder: Amy Wetherby

Funding Agency: National Institutes of Health

About: Autism Navigator® is a web-based instructional program developed at the Florida State University Autism Institute and now provided by Autism Navigator to bridge the gap between science and community practice. Specifically, the Autism Navigator offers a suite of web-based tools and courses to guide families, teachers, therapists, and doctors toward strategies that help support learning. These tools increase the capacity of primary care early intervention and other service providers, as well as families, to better serve young children with or at risk for autism spectrum disorder (ASD). Autism Navigator aims to offer infrastructure that builds capacity to transform community-based systems of health care delivery and education for toddlers with ASD and their families. The company has integrated current research into a highly interactive web platform with extensive video footage to illustrate effective evidence-based practice.

AirLift Environmental (Nebraska)

TSC Member Institution: University of Nebraska, Public

Founding Year: 2012

Founders: Mark Christenson and Dr. Steve Comfort

Funding Agency: Environmental Protection Agency, National Institutes of Health

About: AirLift Environmental, a veteran-owned small business, is based in Lincoln, Nebraska and is dedicated to finding effective, affordable, and timely solutions to groundwater contamination problems. AirLift Environmental's technology uses a groundwater recirculation system that is driven by a pump powered with air, otherwise known as an AirLift pump. The AirLift pump was invented in the 1800s, but never before used in a groundwater remediation system. Additionally, with funding from the National Institutes of Health, AirLift developed and patented direct-push aerated Oxidant Candles for treating contaminated groundwater. AirLift's groundwater contamination solutions have been used to eliminate contamination across a variety of sites such as former industrial manufacturing facilities, former filling stations, leaking underground storage tanks, and former dump facilities.

Tmunity (Pennsylvania)

TSC Member Institution: University of Pennsylvania, Private

Founding Year: 2015

Founders: Carl H. June, Bruce Levine, Yangbing Zhao, Anne Chew, and James L. Riley

Funding Agency: National Institutes of Health

About: Tmunity Therapeutics is a private biotherapeutics company focused on saving and improving lives by delivering the full potential of next-generation T cell immunotherapy to more patients with devastating diseases. Integrating broad collaborations with the University of Pennsylvania (UPenn) with the groundbreaking scientific, clinical, and manufacturing expertise and demonstrated track record of its founders, Tmunity is developing personalized immunotherapies for cancer that are advancing rapidly toward the clinic. With headquarters in Philadelphia, Tmunity utilizes laboratories and production facilities at UPenn and its own dedicated current good manufacturing practice(cGMP) facility in Norristown, PA, to pursue process improvement and production scale-up in support of clinical development of T cell therapies.

risQ, Inc. (Massachusetts)

TSC Member Institution: Northeastern University, Private

Founding Year: 2016

Founders: Colin Sullivan and Evan Kodra

Funding Agency: National Science Foundation

About: risQ was created to address the gap between the corpus of climate change research and actual practice. The founders realized that the private sector was relatively unengaged in the climate change discussion — but that it might be the right vehicle for real change and began exploring the idea of spinning out a company from Northeastern's Sustainability and Data Sciences Lab. In 2016, risQ was awarded its first funding — a $225,000 National Science Foundation Small Business Innovation Research (NSF SBIR) grant — and the company officially launched. In 2017, risQ built an understanding of the catastrophe ("cat") modeling and insurance markets, culminating a technical partnership with JBA Risk Management (a renowned leader in flood modeling), and wide recognition in the cat insurance sector. In 2020, risQ and Intercontinental Exchange (NYSE:ICE), a market leader in data services to the financial services sector, announced a partnership that would enable the municipal bond ecosystem to incorporate best-in-class climate risk into project and investment decisions at a security level. risQ is now a leader in modeling and translating climate risk to the bottom line for municipal debt participants.

Apsidal (California)

TSC Member Institution: University of California, Riverside, Public

Founding Year: 2019

Founders: Amrit De

Funding Agency: National Aeronautics and Space Administration (NASA)

About: Apsidal is a research organization that works on some of the most cutting-edge scientific technologies. Apsidal provides photonics and quantum information solutions to explore the synergy between artificial intelligence (AI) and photonics manufacturing in unusual cutting-edge environments. One of their key innovations is a custom laser doppler sensor for real-time in-situ analysis and feedback control of the glass manufacturing process. The technology was created to optimize production in a low-Earth orbit environment. Apsidal has also created integrated machine vision and optical materials manufacturing technology.

Apsidal's technology has commercial and governmental applications. It recently received funding from NASA for developing a universal glass optics manufacturing module capable of processing various types of complex glass in space from which fibers, magnetic fibers, super-continuum sources, capillary optics, and adiabatic tapers can be drawn. Market areas for products from this module include specialty fibers for communications, medical diagnostics, remote sensing, X-ray optics, and laser processing.

CHALLENGES AHEAD: DECLINING FEDERAL INVESTMENT IN R&D PUTS AMERICAN INNOVATION AND U.S. ECONOMIC GROWTH AT RISK

As detailed in this report, federal research funding plays an important role in fostering economic development and innovation and creating jobs. However, at a time when that funding is as critical as ever, federal funding for research as a percentage of U.S. GDP has declined in recent years.

Although the federal government has long functioned as the key investor in fundamental research, in the past ten years, federal investment in fundamental research, and R&D at large, has slowed. Despite its continued funding of research projects across the U.S., the federal government's research contribution has declined over time.

2020 Federal Government Investing in R&D

Nondefense R&D for research and development in fields like health, space, energy, general science, and natural resources	$73.8 B
Defense R&D, focused on the development, testing, and production of weapons and weapon systems systems.[20]	$65.8 B
Total	$139.6 B

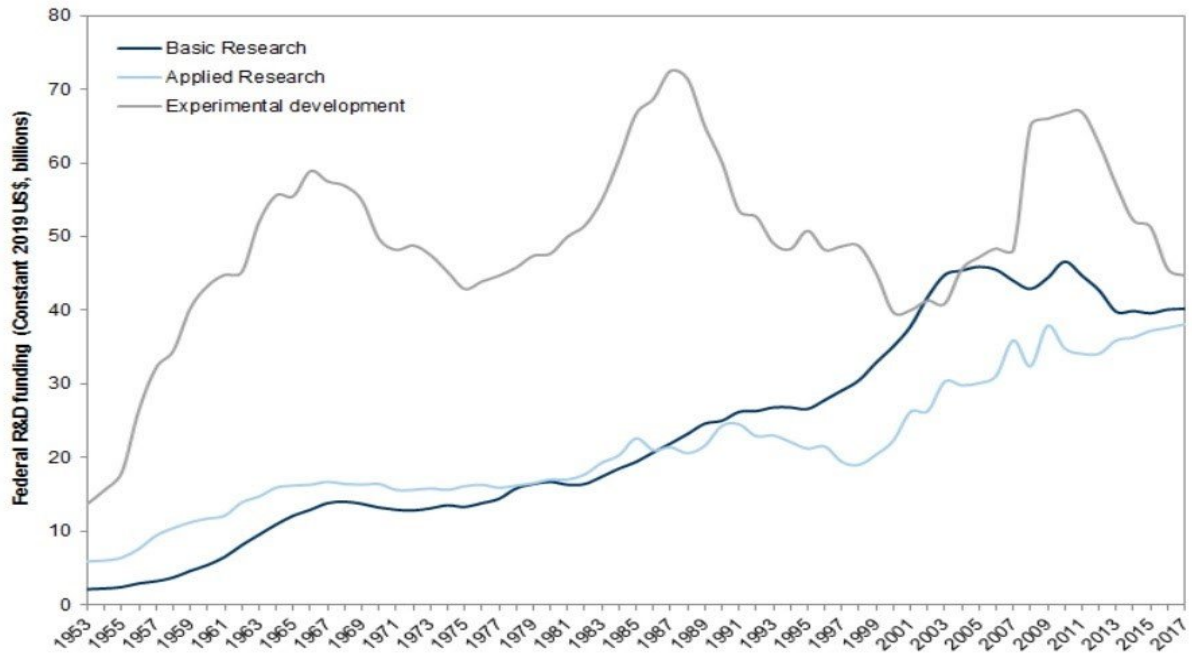
For instance, while the amount of federal R&D funding increased across sectors between 2000 and 2017, the share of total R&D funded by the federal government declined from 25 percent to 22 percent across sectors.[21] Overall, the dollar amount of federal investment in R&D has continuously declined since 2004.[22] More widespread, federal investment in innovation R&D that so directly grows the U.S. economy has declined as a percentage of federal funding since the 1960s.[23] Even funding from NIH, which provided almost half of the funding for fundamental research in 2018, has stalled since the early 2000s.[24] In comparison, other developed countries are increasing their R&D investment. For instance, between 2003 and 2017, China's government R&D spending increased by 330 percent while U.S. R&D spending grew by only two percent.[25]

Table 4: 2020 Fundamental Research Funding Amounts ($ millions)[26]

National Institutes of Health*	20,352.2
National Science Foundation	5,322.0
Department of Energy	5,514.4
National Aeronautics and Space Administration	6,880.0
Department of Defense	2,607.3
Department of Agriculture	1,264.0
All Other	1,411.5
Total Fundamental Research Funding	**43,351.4**

A recent look at federal R&D funding shows a precipitous decrease in funding since 2010. Furthermore, when accounting for inflation, funding of fundamental research dropped 13 percent between 2005 and 2017.[27]

Figure 6: Federal Funding for R&D by Type of R&D



Source: American Association for the Advancement of Science, Goldman Sachs Global Investment Research

The decline in research investment is especially troubling when we look at the immense benefits R&D provides to public health and our economies. Founders and CEOs of spinoff companies expressed that most of them were completely dependent on federal fundamental research funding. **Dr. Josh Smith, a professor of computer science and engineering at the University of Washington and co-founder of Jeeva Wireless, which contributed $20 million in GDP between 2015 and 2019, said the federal funding received in 2011 was "essential to launching Jeeva." According to Dr. Smith, "several years of fundamental research, which led to numerous awards and patents, created the fundamental technology," which includes a battery-free power source that removes batteries as a barrier.** "Then further grants and contracts from the government have allowed the company to take the technology further, turning it in to a real business, creating new jobs," he said. Jeeva Wireless provides ultra-low power communication technology and creates passive backscatter technology which uses 1,000 times less power, costs significantly less, and takes up less space than conventional radios, allowing devices to communicate over standard wireless protocols. In addition to funding the fundamental research, the first investment into the company was from the NSF's SBIR program.

Similarly, the founders of SupraSensor — a company rooted in research from the University of Oregon and whose innovation was funded by the NSF — said the federal government was the only funding source that provided funds that were sustainable enough to get their nitrate marking technology, which helps farmers avoid over-fertilizing their crops, off the ground. SupraSensor's innovation allows farmers to reduce the amount of fertilizer they use and reduce the environmental effects of over-fertilization. SupraSensor's technology has been described by NSF as something that could be used as a "super tool" for precision agriculture by helping farmers to avoid harming other crops and reduce fertilizer waste.[28]

"Federal funding was the sole available mechanism that was risk tolerant and long term enough to prototype SupraSensor's first devices from the initially funded chemical research. Hardware development is capital intensive and requires a longer runway than most early investors are comfortable with."

(TSC Institution: University of Oregon; Federal Agency Funding: National Science Foundation)

Furthermore, the founders of spinoff company Apsidal, highlighted in the previous section, described it as "entirely reliant on federal funding."

In that case, why is federal funding for fundamental research slowing? According to RealClearScience, in the past two decades, the private sector has overtaken the federal government as the largest overall funder of U.S. R&D.[29] Yet, as discussed earlier, much of private sector funding goes toward applied research rather than fundamental research (development, in particular, has experienced a steady increase in funding over the last two decades).

There are several reasons U.S. private sector funders support applied research over fundamental research. An analysis of the impact of R&D investment on economic growth and welfare found that increasing the public investment in fundamental research reduced GDP and welfare growth rates in the short term. Conceivably, short-term losses might make funders reluctant to increase fundamental research funding any further.[30] One reason for those short-term effects is that it often takes years for fundamental research to produce results, which is why the federal government and research college and universities are, despite declines in their support, still more likely to support fundamental research than the private sector.

Enhanced Federal Commitment Will Fuel Innovation for Generations to Come

Amid declining federal investment, the private sector is unlikely to fill the gap in funding for fundamental research. Moreover, there is widespread agreement that funding fundamental research is an inherently federal function, as the private sector is often unable to invest in research without a predetermined outcome or time horizon. U.S. R&D investment patterns demonstrate the private sector's hesitancy to invest in fundamental research. In 2018, the federal government provided 42 percent of all fundamental research funding, followed by the business sector (29 percent), universities (14 percent), and other non-profit organizations (16 percent) (Figure 1). [31]

"Federal funding has enabled the possibility of commercializing this innovative high-risk new technology."

(TSC Institution: University of California, Riverside; Federal Agency Funding: National Science Foundation, Office of Naval Research)

DEEPBITS TECHNOLOGY

But experts know that innovation relies on the experimental knowledge gained through fundamental research. If funding slants toward fundamental research, innovation will follow. As evidence, consider a study published in 2019, which found that one third of all U.S. patents granted since 1970 relied on government-funded R&D. [32]

Furthermore, fundamental research is the clearly identifiable foundation of many tools and applications in use today. Insights like general relativity, which led to the creation of GPS, as well as the scientific findings that led to the development of gene replication technologies, would not exist without fundamental research.[33]

As federal officials and policymakers consider annual budget and appropriations requests, fundamental research funding should be top of mind. The federal government — combined with the brainpower and creativity of researchers and scientists at research institutions — can take ownership for promoting and supporting American innovation that will transform society for the generations to come.

CONCLUSION

Federal fundamental research investment enables universities and research institutions to make discoveries that serve as the backbone of all critical innovations.

By performing close analysis of the economic outcomes of the fundamental research supported by public and private research institutions and related companies, FTI found that fundamental research also leads to millions of dollars in economic activity, thousands of jobs, and boosts economies across the country. In short, federal sponsorship of fundamental research is an investment that provides returns many times over.

The economic benefits of fundamental research are routinely undercounted and the prevailing wisdom that fundamental research has lesser short-term economic benefits is often erroneous. Over just a five-year period, the 53 spinoff companies sampled here have attracted over $1.75 billion in research grants which in turn supported more than 9,000 jobs nationally and contributed $729.0 million to the U.S. GDP, with some companies contributing hundreds of millions in GDP individually. The companies have also paid $115.3 million in federal taxes and $42.9 million in state taxes and, through both indirect and induced effects, many of them created jobs and supported the economies of states they were not based in.

Our findings regarding the economic impact of this sample of companies further prove that federally funded fundamental research has a phenomenal return on investment—both short- and long-term—and that it will be key to revitalizing the economy. By increasing investment in R&D, the federal government could catalyze job growth and increase tax revenues, two outcomes critical to recovering from the economic fallout of the COVID-19 pandemic. According to an analysis by Breakthrough Energy, if the U.S. increased R&D spending to about $315 billion per year by 2030, federal R&D spending could support 3.4 million jobs, $301 billion in labor income, and $81 billion in tax revenue.[34]

As our society and economy recover from the COVID-19 pandemic, it is crucial we prioritize the long-term fundamental research that has allowed us to not only support local economies through job and company creation, but also has supported innovations to combat the pandemic. Thanks to decades-long federal investment in fundamental research, the groundwork was laid for innovations to combat the pandemic, including vaccines and treatments, at a record pace. We cannot let up now. Congress must redouble its commitment to providing predictable, sustained, and robust federal investment in fundamental research to support economic recovery and growth and secure our position as a leader in innovation on the global stage.

APPENDIX

Methods

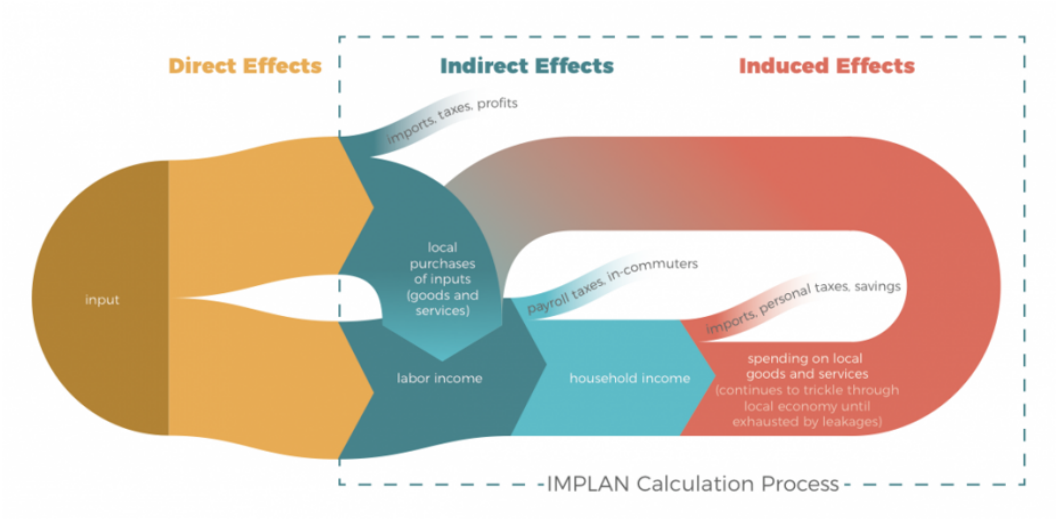
Company Analysis

The input data for FTI Consulting's analysis relied on two datasets provided by TSC, which TSC collected by surveying its member institutions. The first dataset described individual companies created through TSC universities' research and development expenditures from the five-year period from 2015 through 2019. The first dataset ultimately totalled 53 companies across the U.S. and included information about their direct employment and sales, their North American Industry Classification System (NAICS) economic sector, and the grant money they received from any potential source, including federal research grant or private capital.[35]

FTI cleaned this first dataset by looking up the NAICS codes of example companies that were not provided in the survey. FTI also assumed that any company not reporting direct employment had a direct employment of one. FTI simulated the total economic impact, including indirect and induced impacts, of these companies' operations and research using multipliers provided by the IMPLAN model.[36]

The "indirect effect" is the effect a company has on suppliers, for example when a medical device manufacturer purchases equipment, materials, or parts from other manufacturers. The "induced" effect is the effect that a company and its supply chain's employees have on the economy when they spend their paychecks, such as on home improvement or groceries. FTI ran two simulations for each of the 53 companies. The first simulation assessed the economic impacts of companies' direct employment and business sales within their NAICS industry. The second simulation covered the grant money received by the companies and entered IMPLAN as production in the Economic Impact Analysis for Planning (IMPLAN) sector for scientific research services.[37] The direct employment and business sales reflects the operations of these companies, such as management, production, sales, and administration. The grants indicate the research undertaken by these companies from whichever funding sources.[38]

Figure 7: IMPLAN Model Simulation



University Analysis

The second important dataset from TSC was information from a sample of its members about the number of companies created by research expenditures in the past five years. FTI used data from the NSF on research expenditures by TSC's members over the past five years and the resulting dataset to determine the correlation between research funding and company creation.

This yielded one company created for every $59.6 million in research expenditures, or $11.9 million in research expenditures if those expenditures were sustained over a period of five years.

FTI scaled this finding to the total research expenditures of each and all members of TSC to determine the number of companies they created. These companies were assumed to have similar characteristics to the ones from the Company Analysis section, including their distribution across sectors (e.g. mostly in manufacturing and professional services with the other services involved in the sample), as well as their direct employment, business sales, and grant receipts. FTI then simulated the total impact of the universities' research expenditures in a similar manner to that described in the Company Analysis section. The University Analysis section also includes separate components for operational and research impacts.

The economic impact extends into states even without a member university because of intrastate economic relationships. For instance, a pharmaceutical manufacturer in California that grew out one of the schools in the University of California system might have suppliers in Arizona or Oregon. Additionally, the employees of the pharmaceutical manufacturer might take vacations to Las Vegas or Honolulu, which would bring tourist dollars into those economies that first originated with a California firm.

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COMPANIES AT-A-GLANCE

Company	State	Year Founded	TSC University	Employees	Grant Receipts (Millions)	Funding Agency	Innovation
AirLift Environmental, LLC	NE	2012	**University of Nebraska**	2	$2.40	Environmental Protection Agency	Direct-push aerated Oxidant Candles for treating contaminated groundwater.
Apsidal	CA	2019	**University of California, Riverside**	4	$0.40	The National Aeronautics and Space Administration	Custom Laser Doppler Sensor for real-time in-situ analysis and feedback control of the glass manufacturing process. This technology is Artificial Intelligence (AI) assisted to be adaptive to optimize production in a low-Earth orbit environment. Apsidal has also created integrated machine vision and optical materials manufacturing technology.
Autism Navigator	FL	2015	**Florida State University**	6	$0.00	National Institutes of Health	Social communication growth charts, Autism Navigator about Autism in Toddlers Online Course, Autism Navigator How-to Guide for Families Online Course, Autism Navigator for Primary Care Professionals.
Ayar Labs	CA	2015	**Massachusetts Institute of Technology**	70	$8.0	Defense Advanced Research Projects Agency	Optical I/O chiplets for integration with high-performance processor and machine learning chips, to enable optical communication from the chip package. Ayar Labs has also developed a new type of laser module for providing a light source for the chip communications.
Bionet Sonar, Inc.	MA	2016	**Northeastern University**	8	$6.70	Department of Defense, National Science Foundation	Wireless deep brain stimulation device, Ultrasonically connected wearables, High speed modem for underwater communication.
Caballeta Bio	PA	2017	**University of Pennsylvania**	1	$0.00	National Institutes of Health	No response provided.
Cellec Technologies, Inc.	NY	2016	**Rochester Institute of Technology**	7	$3.10	No response provided.	No response provided.

Cognivive, Inc.	CA	2017	**University of California, Davis**	5	$1.50	National Institutes of Health	Derived a set of algorithms from action video game play that have been shown to greatly improve the cognitive processes impaired in the target populations. Based on these initial developments, Cognivive has created several treatment prototypes that are being played and enjoyed as real games, particularly by senior citizens.
Community Forensic Interventions	NY	2013	**University of Rochester**	2	$0.00	National Institutes of Health, National Institute of Mental Health (NIMH)	R-FACT model and training, SAVE training, and FAST training.
Conidiotec, LLC	PA	2014	**The Pennsylvania State University**	6	$0.70	United States Department of Agriculture	Developed a formulation suitable for indoor pest control with active ingredient lifetime up to 90 days.
Cytovale	CA	2012	**University of California, Los Angeles**	15	$44.60	National Science Foundation, U.S. Office of Naval Research, Defense Advanced Research Projects Agency, National Institutes of Health	Ability to analyze 2000 cells/second, proprietary microfluidic cartridge for assessing biomechanical properties, ability to measure and diagnose sepsis based on cellular properties during squeezing events. Machine learning to identify disease signatures and diagnostics.
Deepbits Technology, Inc.	CA	2017	**University of California, Riverside**	3	$2.00	National Science Foundation, Office of Naval Research	Dr.Binary - a Next Generation Threat Management Platform For Software Assets. This one-stop platform solution allows Deepbits to find vulnerability, malware, and code plagiarism in one place. This platform provides analysis on code without the need for source code from the client, builds DNA into every piece of code to effectively look up code reuse, and discover more threats through granular analysis within minutes.

Drone Amplified	NE	2014	**University of Nebraska**	7	$5.40	National Science Foundation	Ignis: a semi-autonomous drone system for planning ignitions and coordinating actions of drone and ignition system without endangering firefighters and operators on the ground. Ignis can operate at night, over dangerous areas, at low altitudes, and in environments where manned operations face significant risks.
Estrigenix Therapeutics, Inc.	WI	2018	**Marquette University**	1	$0.00	National Institutes of Health, General Medical Sciences	Estrigenix has already obtained proof of concept on its patented lead molecule (EGX358) in pre-clinical studies, including both in vitro and in vivo studies. EGX358 will first be developed into a product to treat hot flashes. The company will then develop EGX358 into a treatment for dementia, memory decline, anxiety, depression.
Exyn Technologies	PA	2014	**University of Pennsylvania**	49	$40.00	No response provided.	The first industrial-grade autonomous aerial robot systems for GPS-denied and inaccessible environments. Designed as a scalable, full-stack solution, Exyn, technology enables the deployment of single or multi-robots that can navigate and map 3D environments, without the use of GPS or preloaded maps, on a sliding scale of control from pilot-assisted to fully autonomous.
Exyn Technologies	PA	2014	**University of Pennsylvania**	1	$0.00	National Science Foundation, Army Research Lab, Office of Naval Research, Army Research Office, Defense Advanced Research Projects Agency	No response provided.

FarmSense	CA	2016	**University of California, Riverside**	6	$2.40	National Science Foundation	Autonomous (wireless and solar powered) smart traps, equipped with proprietary sensor (patent pending). The sensor captures signals from flying insects in the field and uploads this data along with environmental information to the cloud. FarmSense's machine learning/AI engine classifies the insects down to the species/sex level (with >95% accuracy) and performs predictive analytics in real time. Customers can track changes in insect population in real-time.
Firefly Photonics	IA	2016	**University of Iowa**	3	$1.00	No response provided.	No response provided.
Instrumems, Inc.	CA	2016	**Princeton University**	5	$8.00	National Science Foundation, Office of Naval Research	New sensory technology capable of measuring velocity, temperature, and humidity of gaseous and fluid flows. This technology has a wide range of applications, and can replace traditional sensors and generate new sensor-driven applications. Instrumems Inc. technology is based on a new nano-wire sensing platform that will allow for faster and cheaper measurement than traditional measuring techniques.
InVivo Biosystems	OR	2014	**University of Oregon**	46	$28.00	National Institutes of Health	Genetic tools (biosensors and CRISPR methodologies), Phenotyping instrumentation and methodologies, Machine Learning algorithms, and using the previous three to determine pathogenicity of genetic variants and the influence drugs have on them.
iota Motion	DE	2015	**University of Iowa**	5	$5.70	No response provided.	No response provided.

Jeeva Wireless	WA	2015	**University of Washington**	13	$20.00	National Science Foundation	Passive backscatter and battery-free technologies to remove battery as a barrier. Jeeva harnesses RF signals to work both as a power source and the means of communication to transmit data with an energy efficiency that is three orders of magnitude lower than any existing solution. Applications include security, occupancy tracking, medical compliance monitoring, electronic shelf labeling and sensing in stores.
Kalion, Inc.	MA	2014	**Massachusetts Institute of Technology**	5	$1.60	ONR Office of Naval Research, National Science Foundation	Increased the titers for glucaric acid production; collaborated with MIT and other universities to identify novel uses for glucaric acid.
KLAR Scientific	WA	2016	**Washington State University**	5	$1.10	National Science Foundation	Autofocus technology (patent), modular optical train, integrated powerplane and compact footprint, analysis software, operating software.
LighTopTech	NY	2013	**University of Rochester**	4	$3.20	National Institutes of Health, National Eye Institute	GDOCM 4D (Gabor Domain Optical Coherence Microscopy) which produces two- and three-dimensional images of many materials including organic tissue, polymers and glass. With GDOCM 4D, nondestructive technology, imaging can be done rapidly and reliably. The technology allows imaging up to a maximum depth of 2 mm for composite materials and 0.6 mm for organic tissue such as skin. The maximum resolution for imaging both materials and organic tissue is 2 micrometers in all dimensions.
Linnaeus Therapeutics	NJ	2016	**University of Pennsylvania**	1	$0.00	National Institutes of Health	Novel small molecule oncology therapeutics, including in a recent clinical trial in patients with advanced cancer.

Locus Biosciences	NC	2015	**North Carolina State University**	39	$170.00	National Institutes of Health, National Science Foundation, United States Department of Agriculture	Currently developing therapies to treat infections of drug-resistant bacteria that are now difficult to treat with antibiotics.
Mammoth Biosciences, Inc.	CA	2017	**University of California, Berkeley**	36	$140.00	National Institute of Health, National Science Foundation	CRISPR based diagnostics (DETECTR), Cas14 family of nano-sized CRISPR systems.
Manifold Robotics	NY	2017	**New York University**	3	$1.60	National Science Foundation	Computer-vision based environmental perception algorithms that will enable unmanned boats to more effectively navigate waterways.
Marquette Energy Analytics, LLC	WI	2018	**Marquette University**	11	$0.00	GasDay, the academic predecessor of Marquette Energy Analytics did not receive federal funding but did get funding from energy industry groups.	Developed and offers forecasting services for: Natural Gas: (1) GasDay forecasts 8 days into the future, which allows LDCs the ability to plan a week in advance. (2) The most detailed of MEA, forecasts, GasHour predicts Natural Gas Usage by the hour over a four-day period. GasHour is often used to track and analyze gas flow in a specific area, and to check storage and balances throughout the day. (3) GasMonth/GasYear is a service that uses long-range weather forecasting (both normal and extreme) to predict natural gas usage up to 840 days ahead. GasMonth and GasYear are often used for hedging, monthly load management, and regulatory filings. (4) Anomalous Measurement Scene Investigator (MSI) analyzes historical flow data to detect erroneous, missing or suspicious readings in natural gas flow data. An LDC can use our anomalous readings reports to correct billing errors before they happen, to improve internal data quality, and to avoid unfavorable publicity. MSI is a cost-effective solution for improving the quality of flow data.

							Electricity: The Electric Power Forecaster predicts a region's hourly electricity usage up to 8 days out. Forecasts are accurate and dependable, simplifying the process for electric utilities and saving time and money. Electric Power Forecaster solution is the newest incarnation of MEA technologies and was created to adapt to the ever-changing energy landscape. Design Day & Custom Studies: The uncertain arrival of peak weather represents a significant risk for energy distribution companies that are expected to anticipate the timing and magnitude of a major event and support all their customers without a hiccup. MEA helps these companies forecast for their design day. MEA can also create and execute hyper-individualized custom studies for its customers. Delivered Fuel: Natural Gas & Oil Tank Forecaster offers highly accurate advice to reduce late deliveries, over and undersupply estimations, and incurred costs associated with Tank fill-ups and Distribution.
OmniLife	DE	1991	**University of Iowa**	6	$2.90	No response provided.	No response provided.
Optimeos Life Sciences	NJ	2016	**Princeton University**	4	$0.30	National Institute of Health, National Science Foundation	Optimeos nano particle encapsulation technology can help therapeutic drugs better target precise locations in the human body. The nanoparticle treatment also allows drugs to have a slow, sustained release that can potentially extend its effects for weeks or months. The treatment has been applied to treatments for diabetes, malaria, and tuberculosis. This marketable innovation can be produced at an industrial scale.

Orchard Therapeutics	CA	2015	**University of California, Los Angeles**	252	$936.50	National Institute of Health, California Institute for Regenerative Medicine (CIRM)	Ability to treat rare, inherited disorders with nonexistent or complicated current treatments. Developments include: enrichment for the specific subset of therapeutic HSCs, gene correction using lentivirus, cryopreservation, and re-introduction of corrected cells without rejection. Together these offer a solution for many patients who previously had few options. While these various techniques are being studied and used in other diseases and gene therapy companies, Orchard has combined them to offer commercially viable and effective treatments.
OscillaVent	IA	2016	**University of Iowa**	3	$0.20	No response provided.	No response provided.
Oscine Therapeutics	WA	2018	**University of Rochester**	1	$0.00	National Institute of Health, National Institute of Neurological Disorders and Stroke (NINDS)	Developed methods to produce glial cells from human stem cell lines by manipulating the chemical signaling of embryonic and induced pluripotent stem cells to create glia. Oscine research has shown that when specific human brain cells are transplanted into animal models of multiple sclerosis and other white matter diseases, the cells repair damage and restore function. Oscine findings demonstrate that the transplantation of human glial cells can effectively achieve remyelination in the adult brain and have significant therapeutics implications as a proof-of-concept for future clinical trials for multiple sclerosis and potential other neurodegenerative diseases.
Pani Clean	WY	2018	**University of Iowa**	1	$0.80	No response provided.	No response provided.

ParaTools, Inc.	FL	2016	**University of Oregon**	8	$0.00	ParaTools received several contracts from the federal government but no federal agency provided funding to establish the company.	Helped develop the TAU Commander tool - an extension to the open source TAU Performance System that simplifies its usage. Also developed KPPA, a Chemical Kinetics simulation tool that speeds up the analysis of air quality assessment software.
RAMDO Solutions	IA	2013	**University of Iowa**	2	$1.10	No response provided.	No response provided.
Rapid Radicals Technology, LLC	WI	2016	**Marquette University**	1	$0.70	National Science Foundation, Water and Equipment Policy Industry-University Cooperative Research Center	Working towards pilot-scale development of the Rapid Radicals Technology system in a municipal setting to provide high-rate treatment during storm events. The technology will reduce the eight hours it currently takes a treatment plant to treat wastewater to under 30 minutes. That is 1500% faster than combined stormwater and wastewater is currently being processed. The technology moves stormwater and wastewater through the conveyance system and safely back into lakes and rivers without fear of infrastructure failure. This technology has the potential to disrupt previously established standards for wastewater infrastructure design, raising the bar for effluent quality and improving the lives of hundreds of thousands of people throughout the world.
risQ, Inc.	MA	2016	**Northeastern University**	12	$2.30	National Science Foundation	Climate conditioned catastrophe modeling for the financial services industry.
Senseion	DE	2019	**University of Iowa**	1	$0.30	No response provided.	No response provided.
SensIT Ventures, Inc.	CA	2015	**University of California, Davis**	3	$0.10	National Science Foundation	SensIT has development agricultural prototype sensors to mitigate food waste in the production supply and chain.

South 8 Technologies	CA	2015	**University of California, San Diego**	5	$6.60	National Science Foundation, National Aeronautics and Space Administration, Department of Education	Novel, patented Liquefied Gas Electrolyte (LiGas), for next-generation electrochemical energy storage devices. These non-toxic electrolytes use solvents that are normally gaseous at standard pressure and room temperature but may be liquefied under a moderate pressure and used as an electrolyte within the cell.
Spirovant Sciences	DE	2016	**University of Iowa**	1	$0.50	No response provided.	No response provided.
Sunthetics	NY	2018	**New York University**	1	$0.80	National Science Foundation	Sunthetics, innovations lie in reactor design and use. The technology is easy to use and implement for chemists and engineers with little electrochemical knowledge. The reactor is modular and can be easily adapted to match the needed reaction conditions. In addition, Sunthetics has developed a machine-learning algorithm to significantly speed up the optimization process through predictive analysis.
Suprasensor Technologies, LLC	OR	2012	**University of Oregon**	10	$0.00	National Science Foundation	Nitrate marking.
Synder Bio	DE	N/A	**University of Iowa**	2	$0.60	No response provided.	
Synlogic, Inc.	MA	2014	**Massachusetts Institute of Technology**	69	$171.10	National Institutes of Health	Synlogic, Synthetic Biotic, medicines are created with smart components designed to address the underlying drivers of disease. These are living medicines therapeutics with the potential to transform treatment paradigms and offer new hope to patients. Synlogic currently has two investigational Synthetic Biotics in the clinic for the potential treatment of PKU and Enteric Hyperoxaluria.
Tesio Pharmaceuticals, Inc.	CA	2017	**University of California, Davis**	8	$0.30	National Institutes of Health	The company is validating the product for the equine market through ongoing research.
Theion Agriculture, LLC	IA	2020	**University of Iowa**	1	$0.20	No response provided.	No response provided.

Tmunity Therapeutics, Inc.	PA	2015	**University of Pennsylvania**	1	$0.00	National Institutes of Health	Tmunity creates smarter T cells designed to overcome tumor microenvironment challenges including T cells designed to overcome prostate cancer, lung cancer, and ovarian cancer.
ViQi	CA	2014	**University of California, Santa Barbara**	10	$2.20	National Science Foundation	Web-based visualization and 3D rendering of complex scientific images, scalable image processing.
WiBotic	WA	2015	**University of Washington**	15	$20.00	National Science Foundation, National Institutes of Health, National Science Foundation	Charging stations for fleets of drones, wireless charging systems, fleet-wide battery monitoring, docking stations for autonomous underwater vehicles, with flexible power transfer range and orientation.