# 2021 New Hampshire University Research and Industry Plan



The 2021 New Hampshire University Research and Industry Plan was commissioned by NH EPSCoR and guided by the NH Research and Industry Council, which serves as the jurisdictional EPSCoR steering committee.

> This plan was formally adopted by the NH Research and Industry Council on September 24, 2021.

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# **1** Letter from NH EPSCoR

Colleges and universities play a key role in transforming new ideas into economic activity directly through local workforce education and production of intellectual property, and indirectly through basic research activities. Although research expenditures often directly support the local economy, commercialization often lags discovery and innovation. Nevertheless, over time through partnerships and strategic investments they provide the foundation to develop innovative products and services that drive economic development.

Many areas in the nation, including New Hampshire, struggle to compete with neighboring high-growth regions because they lack investments in asset resources and capacity-building support. New Hampshire has a solid base of research and talent but it has several gaps, including the lack of venture capital investments and diversification.

The 2021 New Hampshire University Research and Industry Plan (NHURIP) provides a data-driven analysis of research and innovation assets and gaps to guide investment decisions that will strengthen the state's innovation capability. The plan identifies key industry platforms and targeted research areas aligned with those industry strengths for potential collaborative opportunities and sets forth goals and strategies to meet those goals.

The 2021 NHURIP was commissioned and guided by the New Hampshire EPSCoR program. The Established Program to Stimulate Competitive Research (EPSCoR) provides federal funding to develop research infrastructure in smaller or rural states like New Hampshire to support research-based economic development. NH EPSCoR investments have built world-class research facilities, educated hundreds of highly skilled undergraduate and graduate students now in the workforce, and trained teachers in K-12 STEM education.

The plan was formally adopted by the NH Research and Industry Council on September 24, 2021. The NH Research and Industry Council is composed of leaders from the state's business and industry sectors, legislative and executive branches of state government, the public sector, and higher education and provides oversight to NH EPSCoR.

On behalf of the NH EPSCoR program and the NH Research and Industry Council, we present this plan as evidence of our commitment to advance our state's competitiveness in science and engineering and foster partnerships with technology-based businesses that enhance job creation and economic development.

#### Marian McCord, Ph.D.

State Director, NH EPSCoR

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# **2** Executive Summary

America's economy relies on innovation sectors, which leverage university research and innovation to create and advance high-tech industries through human capital development, translation of intellectual property, and development of infrastructure (including as specialized equipment and facilities). However, innovation sectors have historically been concentrated in the nation's dynamic "superstar" metropolitan areas, such as Boston, San Francisco-San Jose, and Seattle. In order to maintain our nation's lead in science and technology, more regions will need to make investments to build their asset resources (including research, talent, and infrastructure), and support provider organizations, which drive innovation growth and cluster development.

New Hampshire is often overlooked from an innovation standpoint. While its overall university research funding is less in comparison to many other states and it lacks a "superstar" metropolitan area, NH does have a solid base of research, intellectual property, and talent to drive high-technology industry development.

However, New Hampshire still needs to fill several gaps including the lack of venture capital investments and diversifying its base of SBIR/STTR awardees to further strengthen the state's innovation capability.

#### New Hampshire has a solid foundationas an innovation-intensive state

46% higher level of university research than the nation adjusted for size of economy Ranked 7th in the nation for Patents Awarded per 1,000 Individuals in Science and Engineering (S&E) Occupations in FY19 (30 for NH vs. 23 for the US)

One of the top five states for R&D expenditure growth (academic, industry, government) from FY2000-2016

12% higher share of high-tech industry employment than the nation

#### But gaps still need to be filled within its innovation ecosystem

Lagging venture capital investment relative to the size of its economy: \$1.14M for NH vs \$6.0M for nation in FY18 Exaggerated national ranking (ranked 19th) in SBIR/STTR awards – 50% of these SBIR/STTR awards have gone to one company The New Hampshire University Research and Industry Plan (NHURIP) is the state's Science and Technology Plan. It provides a roadmap to guide innovation and investment in critical research areas where NH has the capacity to grow. A rigorous quantitative and qualitative data analysis was guided by three areas of inquiry:

- 1. How have New Hampshire's three target industry platforms performed over the past 5 years?
- 2. What are existing and emerging research strengths on which New Hampshire should build? Which criteria should New Hampshire use to select these?
- 3. How can New Hampshire leverage its existing strengths, maximize federal investment opportunities, and address gaps to increase its competitiveness in these research areas?

The NHURIP was initiated by the New Hampshire Established Program to Stimulate Competitive Research (NH EPSCoR) program. The New Hampshire Research and Industry Council (RIC) which includes leaders from NH's academic, industry state government and non-profit sectors provided oversight and guidance. The plan was developed by Keen Point Consulting (KPC), LLC, a technology-based economic development consulting firm located near Cleveland, OH, and its partner, Research Triangle Incorporated (RTI), a non-profit research and consulting firm headquartered in Research Triangle Park, NC.

## **NH Industry Platforms**

An assessment of industry employment, job growth, average annual salary, and innovation data from 2014-2019 showed that Life Sciences, Information Technology, and Advanced Manufacturing remain<sup>1</sup> as the leading drivers of economic growth in NH (Figure ES-1), with compound annual growth rates (CAGR) and average salary higher than the state values.

These three industry platforms also align with three of New Hampshire Division of Economic Development's target industry sectors in its Economic Recovery and Expansion Strategy (ERES) Plan, which is the state's framework for long-term economic growth and success.



#### Figure ES-1: NH Industry Platforms

1 TEConomy Partners and Keen Point Consulting, "New Hampshire University Research and Industry Plan: A Roadmap for Collaboration and Innovation" (2016). New Hampshire EPSCoR. https://www.nhepscor.org/nh-university-research-industry-plan

## New Hampshire Targeted Research Areas

Targeted research areas were identified through an analysis of university and industry research and development (R&D) activity, patenting activity, startup, and venture capital activity from 2011-2019 and university and industry stakeholder interviews.

Nine targeted research areas (Figure ES-2) were selected based on meeting two or more of the following criteria:

- Growing research/education activities (e.g., major centers, star faculty, etc.)
- Alignment with New Hampshire's target industries and workforce needs
- High-priority areas for federal research investment

Additionally, these research areas were mapped to the three targeted platform areas as shown in Figure ES-2 below based on alignment of assets or potential collaborative opportunities. The following key factors were analyzed to determine the research opportunities and resources needed for NH to be competitive in each of the nine targeted areas:

- Strengths to build on from a university and industry standpoint
- Weaknesses or gaps that may hinder New Hampshire's progress in this area
- Research opportunities for potential growth and advancement
- Competition with other states in terms of research/ infrastructure
- Assets like research capacity, major centers, and industry leaders
- Research funding outlook

Next, the previous analysis was used to perform a relative assessment of major assets and potential funding for each of nine research areas for New Hampshire (Figure ES-3) to help prioritize and gauge which resources are currently available and those that may need to be developed in the future.



### Table 2: Relative Assessment of Assets for New Hampshire Research Areas

	CATEGORY			
	Early Career Faculty	Major Facilities/ Specialized Equipment	Industry Presence	4 NSF FY22 Funding Outlook
RESEARCH AREA	<ul> <li>No Early Career Faculty</li> <li>Minimal: 1-2 Faculty</li> <li>Emerging: 3-4 Faculty</li> <li>Established: 5+ Faculty</li> </ul>	<ul> <li>No Major Facilities/ Spec. Equip.</li> <li>Minimal: 1-2 Facilities/Equip.</li> <li>Emerging: 3-4 Facilities</li> <li>Established: 5+ Facilities</li> </ul>	<ul> <li>No Presence</li> <li>Minimal: No growing employment and/or few notable employers</li> <li>Emerging: Growing employment and/or some notable employers</li> <li>Established: High employment and/or multiple notable employers</li> </ul>	<ul> <li>No NSF Funding</li> <li>Minimal: &lt;\$350 M</li> <li>Emerging: \$351-\$700 M</li> <li>Established: \$700 M+</li> </ul>
Biotherapeutics	٠			٢
MedTech				٠
QuantitativeLife Sciences & Bioinformatics	٠		٢	
Environmental Remote Sensing			٢	
System Networks	٠			٢
Data Analytics, AI & Machine Learning		lacksquare		
Advanced Materials				
Computer and Electronic Components	٠			٢
Renewable Energy	٢		٢	

#### CATEGORY

## Goals, Strategies, and Metrics for the NHURIP

The 2021 New Hampshire University Research and Industry Plan goals focus on the important role of university research and development in growing NH's innovation economy. They are informed by and align with New Hampshire's target industry sectors and economic development strategy.

#### By 2026:

- Expand R&D activities and expenditures in target research areas by 10%
- Grow New Hampshire's skilled workforce-ready population with a focus on underrepresented groups in STEM by 5%
- Increase Infrastructure and capacity needed to expand R&D in targeted research areas by 10%

New Hampshire's government, industry, higher education institutions, and non-profits all play a role in advancing these state-level goals. However, the proposed strategies included in Table ES-1 are focused on actions within the purview of the state's higher education institutions and NH EPSCOR. Target percentages will be measured using the indicator metrics included for each goal.

#### **Table ES-1: Proposed Strategies**

GOAL 1

Increase R&D activities (projects, publications) and expenditures in target research areas by 10% by 2026

#### Strategies

- Pursue large grant opportunities
- Prioritize faculty hires
- Increase industry-sponsored research and licensing
- Create collaborative partnerships with stakeholders (primarily undergraduate institutions, state agencies, industry, non-profits)
- Create comprehensive portal of SBIR/STTR proposal technical support across NH
- Fill gaps in SBIR/STTR proposal development funding support (Phase 0 funds, Phase 1 and 2 match)
- Advocate for state supported fund to contribute required match support for large federal grants

- State R&D expenditures
- Growth in faculty/researcher community
- Success of early-career researchers
- Industry sponsored research
- Funded projects
- New or expanded infrastructure
- Increase in SBIR/STTR proposals and projects
- Publications
- New or expanded partnerships
- State support to leverage federal research funding

GOAL 2

Increase NH's skilled workforce-ready population with a focus on underrepresented groups in STEM by 5% growth by 2026

#### Strategies

- Increase internships and applied research experiences, especially for underrepresented students
- Expand universal articulation agreements between USNH institutions and the community colleges focused on STEM disciplines
- Increase awareness and use of existing Universal Pathways (universal articulations/course equivalencies) with critical stakeholders (faculty, staff, parents, teachers, guidance counselors and students)
- Increase transfer student population through recruitment onboarding, ongoing support, tracking metrics, and scholarships
- Strengthen partnerships between NH's higher education institutions and industry to align workforce development efforts
- Leverage partnerships between NH's higher education institutions and industry to co-develop curriculum and programs that address STEM workforce needs
- Increase awareness and access to professional degrees, certifications, and badges that align with STEM workforce skillset needs

- Two-year and four-year STEM degrees conferred
- MS/PhD degrees conferred
- Research experiences and internships
- Companies participating in internship programs
- Demographics of students in STEM programs, internships, and research experiences
- Number of transfer students in STEM programs at four-year institutions
- Success of transfer students in STEM programs
- Curricula, badges, certificates, degree programs aligned with workforce/skillset needs
- New or strengthened partnerships between higher education institutions and industry focused on alignment of workforce development efforts

GOAL 3

Increase infrastructure and capacity needed to expand R&D in targeted research areas by 10% by 2026. For the purposes of this plan, infrastructure includes the talent, centers, projects, physical spaces, partnerships, equipment, and instrumentation needed to grow R&D in the targeted areas

#### Strategies

- Increase grant funding for the purchase of new equipment and instrumentation
- Expand usage of equipment and instrumentation across the state and region
- Provide seed funding and other supports to build multi-stakeholder (faculty, industry, state agencies, non-profits) collaborative project teams
- Prioritize the development of physical spaces and centers focused on targeted research areas
- Prioritize cluster hires
- Partner with industry and state government to leverage support for infrastructure

- Equipment and instrumentation supported by state and federally funded grants aligned to R&D and workforce goals
- Shared use of core facilities
- New or strengthened partnerships between academic institutions, industry, state government that support growth in targeted research areas
- Number of:
  - Publications
  - Proposals submitted
  - Funded projects
  - Equipment and instrumentation acquired or included in proposals and funded projects
  - · Centers developed or under development
  - Physical spaces allocated or created
  - Faculty hires completed or included in funded projects
  - Collaborative teams developed
  - State or federal support for new or expanded infrastructure

**3** Why a University Research and Industry Plan Matters for New Hampshire

According to a Milken institute report, universities play a key role in determining a region's capacity for innovation and to transform new ideas into economic activity directly through local workforce education, production of intellectual property and indirectly through basic research activities.<sup>2</sup> Although they do not provide commercial value immediately, the research activities at universities provide the foundation for helping to create and advance industries (including the high-tech sector) over time through the production of human capital talent for employment and intellectual property that can be commercialized into innovative products and services.<sup>3</sup>

America's future economy lies in its high-technology innovation sectors, but significant technology gains and financial success have primarily reached the nation's dynamic "superstar" metropolitan areas, such as Boston, San Francisco-San Jose, and Seattle and left out places with less innovation activity.<sup>4</sup> These "superstar" metropolitan areas have grown their economy by leveraging innovation and talent (primarily from academic institutions) to build a group of high-value industries in a specialized sector(s) over a period time to form industry clusters.<sup>5</sup>

Many areas in the nation including New Hampshire struggle to compete with "superstar" neighbors because they lack investments in asset resources and capacity-building support that drive innovation growth and cluster development.<sup>6</sup> State government and federal funding programs like National Science Foundation EPSCoR and Economic Development Administration Economic Adjustment Assistance can play a major catalyst role in supporting innovation.

Universities play an important role in determining a region's capacity for innovation and to transform new ideas into economic activity. 2 Milken Institute, "Building a Knowledge Economy – How Academic R&D Supports High-Tech Employment", Sept. 2, 2020, https://milkeninstitute.org/ report/building-knowledge-economy-how-academic-rd-supports-high-tech-employment

3 ibid.

- 4 Brookings Institution, "The case for growth centers: How to spread tech innovation across America", Dec. 2019, https://www.brookings.edu/research/ growth-centers-how-to-spread-tech-innovationacross-america/
- 5 Brookings Institution, "A new federal grant should make regional leaders rethink their industry clusters" Sept. 2021, https://www.brookings.edu/blog/ the-avenue/2021/09/01/a-new-federal-grant-shouldmake-regional-leaders-rethink-their-industry-clusters/

6 ibid.

New Hampshire is often overlooked from an innovation standpoint. However, upon closer review and analysis, New Hampshire does have a very solid foundation of innovation activity including research, intellectual property, and skilled talent to leverage and help grow its economy:

- University research activity in New Hampshire outpaces the nation by more than 46%, given the size of its economy
- New Hampshire ranks in the top five states for R&D expenditure growth (academic, industry, government) from FY2000-2016 (117% change in NH vs. 38% change in US)<sup>7</sup>

- NH is in the top quartile (ranked 7th in the nation) with about 30 patents awarded per 1,000 Individuals in Science and Engineering Occupations in FY19 (US average is about 23)<sup>8</sup>
- New Hampshire stands slightly ahead of the nation in the percentage of jobs in high-tech industries<sup>9</sup> (11.8% in New Hampshire vs 10.5% nationally).<sup>10</sup>

These indicators of New Hampshire's strength across university research, technology development, and the presence of high-tech industries point to the importance of innovation as an economic driver of New Hampshire's economy.



7 NSF, National Center for Sciences and Engineering Statistics, State S&E Indicators

#### 8 ibid. s

9 U.S. Bureau of Labor Statistics (BLS) define high-tech industries as industries such as good-producing or services-producing having high concentrations of workers (i.e., 2.5 times the workers) in STEM (Science, Technology, Engineering, and Mathematics) occupations. In 2016 BLS identified 27 industries (13 goods-producing and 14 service-producing) as high-tech. See the following for further details - https://www.bls.gov/opub/btn/volume-7/high-tech-industries-an-analysis-of-employment-wages-and-output. htm#:~:text=There%20are%20various%20ways%20that%20high-tech%20industries%20can,in%20STEM%20%28Science%2C%20Technology%2C%20Engineering%2C%20 and%20Mathematics%29%20occupations.

In order to strengthen and grow New Hampshire's innovation capacity there are gaps that need to be filled. The state ranked 29th in the nation in FY19 for venture capital investment relative to the size of its economy.<sup>11</sup> New Hampshire is ranked 19th nationally in FY18 SBIR/STTR awards, but this indicator is exaggerated because 50% of these awards have gone to one company.<sup>12</sup> These gaps show that NH is still struggling to translate its base of research and ideas into commercialized products and services into a broad base of high-technology businesses to help grow its economy.

Ensuring that New Hampshire can strengthen its high-technology industries is critical. The 2021 University Research and Industry Plan outlines findings and recommendations to identify New Hampshire's university research strengths that can be leveraged to help build its high-technology industries.

The NHURIP is the state's Science and Technology Plan. It provides a roadmap to guide innovation and investment in critical research areas where New Hampshire has the capacity to grow. A rigorous quantitative and qualitative data analysis was guided by three areas of inquiry:

- 1. How have New Hampshire's three target industry platforms performed over the past five years?
- 2. What are existing and emerging research strengths on which New Hampshire should build? Which criteria should New Hampshire use to select these?
- 3. How can New Hampshire leverage its existing strengths, maximize federal investment opportunities, and address gaps to increase its competitiveness in these research areas?

The NHURIP was initiated by the New Hampshire Established Program to Stimulate Competitive Research (NH EPSCoR) program. The New Hampshire Research and Industry Council (RIC) which includes leaders from academia, industry, state government, and non-profit sectors, provided oversight and guidance. The plan was developed by Keen Point Consulting (KPC), LLC, a technology-based economic development consulting firm located near Cleveland, OH, and its partner, Research Triangle Incorporated (RTI), a non-profit research and consulting firm headquartered in Research Triangle Park, NC.  Ensuring that New Hampshire can strengthen its high-technology industries is critical. **4** Assessment of New Hampshire Industry Platforms

## Figure 1. Three New Hampshire Industry Platforms

## 4.1 Industry Assessment

In 2016, Life Sciences, Information Technology, and Advanced Manufacturing were the top three industry sectors in NH. An assessment of industry performance and innovation data five years later confirm that these three sectors remain leading drivers of economic growth in NH (Figure 1).

## 4.2 Life Sciences Platform

New Hampshire's life sciences sector includes health care and the biosciences. Based on employment, health care is the third largest employment sector in the state.<sup>13</sup> Including biosciences, life sciences provide 72,441 jobs just surpassing advanced manufacturing as the top employment sector in the state.

Significant health-care organizations include Dartmouth-Hitchcock Medical Center, which is the largest employer in the state, and other medical centers including Southern New Hampshire Medical Center in Nashua, Concord Hospital in Concord, and Elliot Hospital in Manchester.



Source: U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics

#### **Industry Performance**

At 12.2%, the life sciences industry had the largest 2014-19 compound annual growth rate (CAGR) period among the three NH industry platform areas. The CAGR was driven by increases in health care (64,018 jobs in 2019, 2.1% CAGR from 2014-19) and the biosciences (8,423 jobs in 2019, 12.6% CAGR from 2014-19), which exceeded growth across all the industry sectors in the state during this five-year period (1.4% CAGR 2014-19).

Double-digit growth in the biosciences was driven by increased employment led by local companies such as Lonza and Novo Nordisk.

The biosciences are an emerging industry with a growing presence of small- to medium-sized companies. These companies provide employment across four of the five industry segments identified in the ninth biennial TEConomy/BIO report:<sup>14</sup>

- Research, Testing, and Medical Laboratories
- Medical Devices and Equipment
- Bioscience-Related Distribution
- Drugs and Pharmaceuticals).

The only biosciences industry segment in NH with no significant employment is Agricultural Feedstock and Industrial Biosciences.

#### **Average Annual Pay**

The 2019 average annual pay for the healthcare (\$70,566) and biosciences (\$95,676) industry segments is greater than the average annual pay (\$59,543) for all the industry sectors in New Hampshire. In both segments, the high average annual pay is driven by personnel with advanced professional and doctorate degrees. The biosciences are an emerging industry with a growing presence of small- to medium-sized companies.

#### **Innovation Activity**

Innovation activity for the life sciences industry in New Hampshire is diversified and cuts across various industry segments in biosciences and health care. During the 2016-20 period:

- New Hampshire had 434 patents by assignee issued to companies such as Deka Products and 206 Ortho in the medical technology category, which is the second highest number of patents after the measurements category (438 patents).
- Health care was the second leading sector<sup>15</sup> for New Hampshire venture capital investment with 29 deals to 17 companies, such as Adimab.
- SBIR/STTR award activity shows several life sciences companies, such as Celdara Medical and DoseOptics, winning awards for bioscience and health-care related technologies. Celdara was the leading life sciences company in total SBIR/STTRs during this period with 20 awards involving vaccine and therapeutics technologies.

<sup>14</sup> TEConomy/BIO – "The Bioscience Economy; Propelling Life-Saving Treatments, Supporting State & Local Communities" (2020), https://www.bio.org/sites/default/ files/2020-06/BIO2020-report.pdf

<sup>15</sup> Information Technology was the leading sector NH venture capital investment with 47 deals to 32 companies

## 4.3. Information Technology Platform

The information technology (IT) platform in New Hampshire provides 37,339 jobs at companies:

- Developing hardware and software
- Integrating these components into systems
- Providing IT support, cybersecurity, and/or networking

Many in this sector are employed at IT and tech companies such as Bottomline Technologies, Oracle Dyn, PC Connection or AutoDesk. Others are employed in IT roles for organizations focused on other industries, such as Fidelity Investments and Lincoln Life Insurance.

Information technology is an established industry in the state with the largest representation of employment in the following occupations according to the CompTia "CyberStates 2021" report:<sup>16</sup>

- Software, Programmers, Web and QA (11,558 workers)
- Cybersecurity and Systems Analysts and Engineers (3,470 workers)
- Network Administrators, Architects and Support (3,278)
- IT Support Specialists (3,186 workers)
- Database, Data Scientists and Computer Scientists (642 workers)

#### **Industry performance**

Information Technology had the second largest compound annual growth rate (CAGR) at 3.3% for the 2014-2019 period. The increase was driven by growth in:

- Management and technical consulting services (4,579 jobs in 2019, 4.1% CAGR from 2014-19)
- Software publishing (3,659 jobs in 2019 and 3.3% CAGR from 2014-19).

#### Average Annual pay

The average annual pay in 2019 for the Information Technology sector is \$52,578 higher than the average annual pay (\$59,543) for all the industry sectors in NH. This significantly higher average is driven by occupations such as cybersecurity, networking, and software development.

#### **Innovation Activity**

Both major technology players and small businesses are driving advances in this area. During the 2016-2020 period, NH had 1,084 patents by assignee in the electrical engineering category with 55% (or 592) of the patents in a sub-classification primarily associated with information technology (Table 1).

## Table 1: Patent Classifications Associated with IT in NH (Shown in bold below)

Patent Class	No. of NH Patents Assigned (2016-2020)
Digital communication	263
Computer technology	214
Telecommunications	187
Electrical machinery, apparatus, energy	144
Audio-visual technology	86
Semiconductors	85
Basic communication processes	58
IT methods for management	47
Total NH patents in the electrical engineering category associated with it	592

New Hampshire's top 10 assignees of patents in the electrical engineering category associated with information technology for the 2016-2020 period include:

- Dartmouth College (48)
- University of New Hampshire (10)
- Parallel Wireless, Inc. (73)
- Collision Communications, Inc. (39)
- Centripetal Networks, Inc. (33)
- Position Imaging, Inc. (24)
- Bottomline Technologies Inc. (11)

Information technology was the leading sector in New Hampshire for venture capital deals for the 2016-20 period. During that time 32 IT companies received 47 deals. Award activity during the same period shows only a small amount of funding to two of the top 10 SBIR/STTR awardees, Creare for robotics and Solid- State Scientific for software, associated with information technology-related efforts.

## 4.4. Advanced Manufacturing Platform

Advanced manufacturing is one of the top three industry employers in New Hampshire. In 2019, 49% of the 71,459 advanced manufacturing jobs were focused on computer and electronic product manufacturing, fabricated metal product manufacturing and machinery manufacturing supply. Advanced manufacturing companies ranked among the top 50 largest employers in New Hampshire include Hypertherm (ranked 21), NH Ball Bearings (ranked 31), and BAE Systems (ranked 48).<sup>17</sup>

#### **Industry Performance**

Compared to life sciences and information technology, advanced manufacturing had the slowest CAGR from 2014-19 at just 1.5% (or 5,007 more jobs). This is only 0.1% better than the CAGR (1.4%) for all sectors in New Hampshire during this period.

Growth was primarily driven by jobs in the following manufacturing industries:

• Computer and electronic product manufacturing (2045 jobs, 2.7% CAGR from 2014-19)

 Advanced manufacturing is one of the top three industry employers in New Hampshire.

- Transportation equipment manufacturing (624 jobs, 5.6% CAGR from 2014-19)
- Electrical equipment and appliance manufacturing (532, 2.7% CAGR from 2014-19)
- Chemical manufacturing (515, 4.9 CAGR from 2014-19)

Growth in these four subsectors accounted for 74% of the net gain in jobs from 2014-19 and offset the 594 total job losses from other areas such as machinery, paper, and printing manufacturing during this time.

Only the beverage and tobacco product manufacturing subsector had double-digit growth for the period (10.9% CAGR or 512 total jobs). The transportation equipment and chemical manufacturing subsectors also showed significant growth in 2019 (5.6% CAGR or 624 total jobs and 4.9% CAGR or 515 total jobs, respectively).

#### **Average Annual Pay**

The average annual pay for advanced manufacturing was \$13,464 greater than the average annual pay (\$59,543) for all sectors in New Hampshire. This higher average annual pay for advanced manufacturing is driven by the demand for employees who are skilled in computer and electronic product manufacturing.

The average annual pay for advanced manufacturing was \$13,464 greater than the average annual pay (\$59,543) for all sectors in New Hampshire.

#### **Innovation Activity**

Innovation activity is differentiated by the type of technology being developed, and these leading-edge technologies are primarily being developed by larger, more established businesses. During the 2016-20 period, 804 advanced manufacturing patents were awarded with 39% of them related to two subsectors: Machine Tools and Other Special Machines. The leading patent assignees for the 2016-20 are notable New Hampshire companies. Hypertherm has been assigned 55% or 75 of the patented innovations in the Machine Tools Category. BAE Systems and Sig Sauer have developed 41% or 77 patented innovations relevant to the Other Special Machines category.

For the 2016-20 period, New Hampshire's advanced manufacturing sector did not have any venture capital activity. With respect to SBIR/STTR activity during the same period, New Hampshire had three, top 10 awardees, Creare, Mentis Sciences, and Warwick Mills, all receiving funding to help commercialize materials-related technology for the advanced manufacturing area.

## 4.5 Concluding Thoughts Regarding Industry Platforms

Life sciences, information technology and advanced manufacturing align with three of New Hampshire Division of Economic Development 's target industry sectors<sup>18</sup> and the 2016 NH University Research and Industry Plan developed for NH EPSCoR.

As you will see in the following sections of this report, these sectors' long-term competitiveness and growth are influenced by the state's research enterprise, including university research and applied research experiences for students. **5** New Hampshire's Targeted Research Areas and Profiles

Targeted research areas were identified based on an analysis of university and industry research and development (R&D) activity, patenting activity, startup, and venture capital activity since 2011, and interviews with university and industry stakeholders.

Nine targeted research areas (Figure 2 were selected based on meeting two or more of the following criteria:

- Growing research/education activities (e.g., major centers, star faculty, etc.)
- Alignment with NH's Target Industries & Workforce Needs
- High-priority areas for federal research investment

The following section provides an analysis of key factors for each targeted research area including:

- Strengths to build on from a university and industry standpoint
- · Weaknesses or gaps that may hinder NH's progress in this area
- · Research opportunities for potential growth and advancement
- External conditions that may influence progress
- Assets like research capacity, major centers, and industry leaders
- Research funding outlook

#### Figure 2: New Hampshire Industry Platforms and Targeted Research Areas





## **5.1 Biotherapeutics Manufacturing**

Biotherapeutics manufacturing involves the development, testing, commercial translation, and manufacturing of drug therapy products (also called biotech drugs or biologics), such as recombinant proteins and hormones, monoclonal antibodies (mAbs), cytokines, growth factors, gene therapy products, vaccines, cell-based products, gene-silencing/editing therapies, tissue-engineered products, and stem cell therapies produced or extracted from a biological source.<sup>19</sup> Due to advances in research and manufacturing, biotherapeutics is one of the fastest growing segments for the pharmaceutical industry.

Biotherapeutics is an emerging area for NH with small hubs of activity occurring throughout the whole technology development lifecycle by academia and industry with an emphasis on the biomanufacturing of tissues and the development of cell-based products.

#### Strengths

NH has a small, but growing biotherapeutics manufacturing employment base (1,634 employees; 7.1% CAGR, 2014-19) anchored by established companies like Lonza, Novo Nordisk, LSNE Contract Mfg., and startups like Adimab. Since the development of the 2016 NH University Research and Industry Plan (NHURIP), NH has established the Advanced Regenerative Manufacturing Institute (ARMI) and the NH Center for Multiscale Modeling and Manufacturing of Biomaterials (NH BioMade) as part of its biotherapeutics manufacturing infrastructure. This expanded research and development base is conducting research projects such as mammalian cell culture optimization to help support stakeholders in academia and industry. Dartmouth-Hitchcock Medical Center leverages its reach throughout the state to facilitate clinical activity with biotech companies in neurology, rheumatology, oncology, etc.

Due to advances in research and manufacturing, biotherapeutics is one of the fastest growing segments for the pharmaceutical industry.

Research strengths include:

- Therapeutic Proteins: Biology of new targets; cell engineering, protein expression, protein production; metabolite exchanges; cell therapy; CART-T; critical quality attributes; computational approaches
- 2) Functional biomaterials: Protein-based materials; tissue engineering, manufacturing proteins; cellmaterial interactions, e.g., interface of biomaterials and immune system; machine learning approaches for experimental and computational work

#### Weaknesses

A gap for NH in this area is translating research. There has been little venture capital (VC) activity despite the fact that Health Sciences and Biological and Biomedical is the largest R&D field at Dartmouth and second largest at UNH behind Atmospheric and Ocean Sciences.

Dartmouth does have some translational research activity with Celdara Medical taking a handful of Dartmouth discoveries through preclinical stage, but the absence of a medical school at UNH limits more translational research from occurring overall in the state. Over the last five years, there has been only one biotherapeutics venture capital (VC) deal. Adimab, a Dartmouth antibody discovery and optimization platform company received \$45M in VC capital.



#### Opportunities

NH has an opportunity to invest and leverage strengths in therapeutic proteins and functional biomaterials research and commercialization activity. One potential research theme is bioprocessing 4.0, which seeks effective, integrated approaches to:

- Manufacture cells
- Identify specific cell types for manufacture
- Optimize biomanufacturing (cellular engineering) and scale up of cellular and protein-based materials

Additionally, NH benefits from its close proximity to Boston biotech companies/ecosystem and Dartmouth's active angel investor network to help support startup creation and growth.

#### **External Conditions**

NH's competitor regions (e.g., greater Boston, New York City, Washington, DC/Maryland, Raleigh-Durham, NC) have multiple academic medical centers that are significantly larger. Additionally, other states are implementing bio/life science industry strategies to continue to grow in this area such:

 Massachusetts – This state's strategy is anchored by two major efforts to support the life sciences sector, the Massachusetts Life Sciences Center (MSLC) and the Massachusetts Biotechnology Research Institute. The MSLC is a public-private agency of the Commonwealth of Massachusetts created in 2007 to bring together industry, university, and government stakeholders in this sector. It has deployed over \$700 M in investments through state grants, loans, capital infrastructure investments, tax incentives, and workforce programs. The Massachusetts Biotechnology Council (MassBio) is a non-profit organization providing services and support to more than 1400 members involved with the life sector through advocacy, innovation services, and networking/outreach events. In addition to these organizations, Massachusetts has a strong academic research base, ranking #1 in FY20 NIH funding in the biopharma area.<sup>20, 21</sup> The state's strong industry presence is being bolstered by companies such as Bristol-Myers Squibb (BMS) leasing facilities in Cambridge for occupancy starting in 2022 and Resilience, a La Jolla, CA-based provider of biopharma manufacturing services that purchased Sanofi's 310,000 square foot manufacturing plant in early 2021.<sup>22</sup>

 North Carolina – Key life science organizations include a major state funded biotechnology center, North Carolina Biotechnology Center (NCBiotech) and a biotech organization, NC BIO. NCBiotech is non-profit organization that was funded by the state 37 years ago to help grow North Carolina's economic development by supporting innovation, commercialization, education, and business growth in the state's life science strengths. NCBIO promotes the growth and development of the bioscience industry in North Carolina through advocacy and networking for more than 200 members. North Carolina also a has strong academic research base, ranking fifth in NIH funding (2,803 awards totaling \$2.308 billion) for the biopharma area.<sup>23</sup> The state's industry presence in this sector is growing through gene and cell therapy expansion by Biogen (Research Triangle Park), Astellas Pharma-owned Audentes Therapeutics (Sanford, NC), bluebird bio (Durham), Novartis Gene Therapies (formerly AveXis; RTP), and Pfizer (Sanford).<sup>24</sup>

#### Assets

#### Early Career Faculty:

Biotherapeutics is a research area with a minimal number of NSF Early Career Faculty from New Hampshire. There was only one awardee with an associated topic from 2016-21.

22 "Top 10 U.S. Biopharma Clusters" - https://www.genengnews.com/topics/drug-discovery/top-10-u-s-biopharma-clusters-8/ 23 ibid.

<sup>20 &</sup>quot;Top 10 U.S. Biopharma Clusters" - https://www.genengnews.com/topics/drug-discovery/top-10-u-s-biopharma-clusters-8/

<sup>21</sup> Biopharma includes biotechnology, disease diagnosis, drug delivery, drug development, drug discovery, drug manufacturing, pharmaceutical distribution and wholesale, and pharmaceuticals/drugs.



#### **Major Centers/Specialized Equipment:**

- Advanced Regenerative Manufacturing Institute (ARMI)
- Biotechnology Innovation Center (UNH)
- NH Center for Multiscale Modeling and Manufacturing of Biomaterials (UNH/Dartmouth)
- Dartmouth-Hitchcock Norris Cotton Cancer Center (Dartmouth)

#### **Notable Industry Presence in NH:**

- Celdara Medical: Leads the Driven Accelerator Hub for biotech a cceleration. NH is one of five northeast states involved in this NIH-funded consortium (Lebanon)
- Adimab: Dartmouth antibody discovery and optimization platform company and has raised \$45M in VC and is valued at over \$500M (Lebanon)
- Lonza: Manufactures mammalian biopharmaceuticals and cell therapies (Portsmouth)
- Novo Nordisk: Pharmaceutical company developing solutions for rare blood diseases (West Lebanon)
- Avitide: Dartmouth faculty start-up biotechnology company focused on biopharmaceutical solutions (Lebanon)

#### **Research Funding Outlook**

#### **Key Driver(s):**

- Diagnostic, Vaccine, and Therapeutic R&D is one of the four R&D focus areas linked to public health & innovation for the Federal FY2022 budget.<sup>25</sup>
- National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) is a Manufacturing USA<sup>®</sup> institute sponsored by the Department of Commerce. It is a public-private partnership designed to accelerate innovation in the U.S. biopharmaceutical industry. In July 2021, the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) made two awards totaling \$153 M to NIIMBL. The first award (\$70M over five years) is to continue driving innovation in developing domestic biopharmaceutical manufacturing processes that can be scaled up quickly and are less reliant on foreign supply chains. The second award for (\$83M over three years) from the American Rescue Plan will support research and development to prevent, prepare for, and respond to coronavirus outbreaks.

Diagnostic,
 Vaccine, and
 Therapeutic
 R&D is one of
 the four R&D
 focus areas
 linked to public
 health & inno vation for the
 Federal FY2022
 budget.

In NH, MedTech is an established area with a specialized concentration of jobs in the medical device and equipment subsector.

#### **NSF FY22 Budget Request:**

• Part of the Biotechnology request (\$324.61M) to include research and infrastructure for biotherapeutics topics such as genomics, proteomics, synthetic biology, chemical biology, etc.

#### FY22 President's Budget:

• Includes \$6.5B to establish the Advanced Research Projects Agency for Health (ARPA-H). ARPA-H's initial focus would be on cancer and other diseases such as diabetes and Alzheimer's.

## 5.2 MedTech

MedTech is a segment of the biosciences that involves the design and manufacture of medical instruments and supplies, lab equipment, and diagnostic technology (e.g., ultrasound equipment, imaging technology).

In NH, MedTech is an established area with a specialized concentration of jobs in the medical device and equipment subsector. According to the 2020 TEConomy/Bio report on "The Bioscience Economy,"<sup>27</sup> New Hampshire was one of only 13 states in the US specialized in medical devices and equipment. The Manchester-Nashua Metropolitan Statistical Areas (MSA)<sup>28</sup> is one of the top medium MSAs (total private employment between 75,000 and 250,000) in the nation. It ranked 14th with a 2018 employment location quotient (LQ)<sup>29</sup> of 2.06, which is two times the national average.

#### Strengths

According to the 2020 TEConomy/BIO report, MedTech has a small overall employment base (2,600 employees in FY2018) in New Hampshire, but it is one of thirteen states in the nation with a highly specialized concentration of employment in this area relative to the size of the state. Since 2016, nine New Hampshire startups have received venture capital in the MedTech area including AgaMatrix and Cairn Surgical. The largest venture capital deal was an \$85M Series C round of funding to Conformal Medical for an atrial closure implant.

26 Deltek - https://iq.govwin.com/neo/marketAnalysis/view/FY-2022-Presidents-Budget-Request--GovWin-FMAs-First-Take/5969?researchTypeId=1&researchMarket=

27 TEConomy/BIO – "The Bioscience Economy; Propelling Life-Saving Treatments, Supporting State & Local Communities (2020), https://www.bio.org/sites/default/files/2020-06/BIO2020-report.pdf

28 Metropolitan statistical area (MSA) – An area containing a large population nucleus and adjacent communities that have a high degree of integration with that nucleus. This classification provides a nationally consistent set of delineations for collecting, tabulating, and publishing Federal statistics for geographic areas. -- https://www.federalregister.gov/documents/2021/01/19/2021-00988/recommendations-from-the-metropolitan-and-micropolitan-statistical-area-standards-review-committee

29 State and regional location quotients (LQs) - "measure the degree of job concentration within the region relative to the nation. States or regions with an LQ greater than 1.00 are said to have a concentration in the subsector. When the LQ is significantly above average, 1.20 or greater, the state is said to have a "specialization" in the subsector" - https://www.bio.org/sites/default/files/2020-06/BI02020-report.pdf (p. 35).



Research strengths include:

- Biomaterials: Multifunctional materials for drug delivery, treatment, and tissue engineering (NH BioMade and ARMI)
- Imaging: Robotic surgical image guidance, diagnostic imaging (Dartmouth Center for Comparative Effectiveness Research (CER) in Cancer Imaging), and real-time imaging of radiation therapy
- Smart health: Wearable sensors and data analytic techniques to understand and predict neurological, neuromuscular, and mental health disorders (AI and Mental Health Lab at Dartmouth)

#### Weaknesses

Although UNH has the Center of Biomedical and Bioengineering Research, it has no bioengineering department, which contributed to having no bioengineering R&D expenditures in FY19. Dartmouth had \$12.8M in bioengineering research in FY19, which is the largest engineering subfield from a research standpoint, but this is the only significant presence of bioengineering research at academic institutions in the state. Therefore, as a result, much of the state's bioengineering research activity has its origins in New Hampshire's Upper Valley region near Dartmouth and does not leverage complementary resources across the state.

Another weakness in this area is that NH BioMade is a "make, model, measure" initiative composed of chemists, engineers and one biologist. Different faculty expertise is required to test and translate biomaterials research into MedTech applications.

#### **Opportunities**

An opportunity exists to foster greater MedTech startup activity and growth through New Hampshire's tech sector strengths, the Dartmouth-Hitchcock Medical Center, and the megatrend of IT and medical device convergence. New Hampshire has an additional opportunity to advance the NH Tech Alliance's BioMedTech Cluster to develop a more comprehensive state strategy and a dedicated NH Bio organization.

Potential research themes to leverage NH's existing research capabilities for this area include:

- Imaging/diagnostic automation and autonomy with a specific focus on sensors, imaging, and artificial intelligence (AI)
- Machine learning for data processing/diagnosis.

### **External Conditions**

New Hampshire's specialized concentration of jobs in MedTech may be adversely impacted by four other northeastern

states (MA, DE, CT, and NJ) that are also specialized in medical devices and equipment.

#### Assets

#### **NH Early Career Faculty:**

MedTech is a research area with an emerging number of NSF Early Career Faculty from New Hampshire. There were four awardees with associated topics in this area from 2016-21.

#### **Major Centers/Specialized Equipment:**

- UNH Center for Biomedical and Bioengineering Research (one of the Centers of Biomedical Research Excellence (COBRE) funded by the National Institute of Health)
- Biomedical Engineering Center (Dartmouth)
- Center for Imaging Medicine (Dartmouth)
- Neuroscience Center (Dartmouth)
- NH Center for Multiscale Modeling and Manufacturing of Biomaterials (NH BioMade) (UNH/Dartmouth)



#### **Notable Industry Presence in NH:**

- Deka Research and Development Corp: A leading research and development firm founded by Dean Kamen that develops innovative technologies with many focused in the medical devices area (Manchester)
- 206 Ortho: Developed and patented a unique bioresorbable, high strength material to repair broken bones (Deerfield)
- Simbex: Medical device and consumer health product design and development partner (Lebanon)
- Lamprey Networks, Inc.: Provider of a variety of hardware and software solutions to provide alerts and analytics for remote monitoring (Durham)

#### **Research Funding Outlook**

#### **Key Driver(s):**

- Biomedicine and Biotechnology is one of the four R&D focus areas linked to public health and innovation for the federal FY2022 budget.<sup>30</sup>
- The COVID-19 pandemic has brought increased focus on health IT investments to improve care, provide better patient outcomes, reduce fraud, and gain efficiencies.<sup>31</sup>

#### **NSF FY22 Budget Request:**

 A portion of the Biotechnology request (\$324.61M) will include research and infrastructure for MedTech areas such as bio probes, bio-based microelectronics, data analytics, etc.

#### **FY22 President's Budget:**

 Biomedical research will be supported through the promotion of a \$52B budget for NIH, a \$9B increase over FY 2021.<sup>32</sup> A portion of the Biotechnology request (\$324.61M) will include research and infrastructure for MedTech areas such as bio probes, bio-based microelectronics, data analytics, etc. >>

<sup>30</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/Public-Health-Security-and-Innovation-Top-the-List-of-Federal-R&D-Priorities-for-the-FY-2022-Budget/4451?researchTypeId=1

<sup>31</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/Deltek-Predicts-Strong-Federal-Health-IT-Market-over-the-Next-Three-Years/6139?researchTypeId=1&researchMarket=

<sup>32</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/FY-2022-Presidents-Budget-Request--Gov-Win-FMAs-First-Take/5969?researchTypeId=1&researchMarket=

## **5.3 Quantitative Biology & Bioinformatics**

The area combines quantitative biology, which is focused on utilizing mathematical, statistical, and computational techniques from multiple research areas to study life and living organisms, and bioinformatics, which is the science of collecting, analyzing, and storing complex biological data, such as the human genome.

Quantitative biology and bioinformatics is an emerging area in New Hampshire with research activity occurring through centers at Dartmouth and UNH. There is also workforce training at University New Hampshire-Manchester (UNH-M) through professional degree programs such as a data science graduate certificate.

#### Strengths

Data to identify the portion of computer science (R&D) activity specific to quantitative biology and bioinformatics is not available for academic institutions in New Hampshire. However, computer sciences is a leading R&D subfield at Dartmouth with \$15.8M in research spending. Major academic research centers in quantitative biology and bioinformatics include the Dartmouth Center for Quantitative Biology (one of the Centers of Biomedical Research Excellence (COBRE) funded by the National Institute of Health (NIH)) and Dartmouth's Department of Biomedical Data Science which utilizes big data to predict disease, improve drug discovery, and enhance patient outcomes.

Research strengths include:

- Analysis of medical and health data (e.g., patient outcomes)
- Machine learning and predictive analysis (e.g., mental health and software tools for tracking and predicting disease outbreaks)
- Digital biomarkers in neuroscience and psychiatry

UNH has growing capabilities in quantitative biology and bioinformatics at the UNH Hubbard Center for Genome Studies which has a sequencing core and bioinformatics core. The UNH Hubbard Center is starting to expand its talent and expertise in the quantitative biology and bioinformatics area with the addition of a new faculty member in the fall 2021 from IBM Watson, which is IBM's product area that provides artificial intelligence (AI) tools, applications, and solutions to help end users automate and optimize their operations.

Quantitative
 biology and
 bioinformatics
 is an emerging
 area in New
 Hampshire with
 research activity
 occurring
 through centers
 at Dartmouth
 and UNH.



#### Weaknesses

Computer science R&D is a very small part of UNH's research expenditures at \$0.9M in FY19, which is only 0.6% of UNH's total R&D activity of \$149M. Another challenge for securing and diversifying sources of research funding from federal agencies such as the National Institutes of Health in this area is the absence of a medical school at UNH.

#### **Opportunities**

New Hampshire has opportunities to expand research in human genome mapping, modeling of the human brain, and molecular profiling. Research and applications in these areas generate big data requiring new computational and computing approaches to test biological hypotheses.

A potential research theme is microbial community assembly. Research topics may include microbial evolution, ecology, genomics, or microbial community assembly that becomes antibiotic resistant.

#### **External Conditions**

There are many global market leaders in quantitative biology and bioinformatics research including Nimbus Discovery (MA); Certara (NJ); Simulations Plus (CA) and Strand Life Sciences (India).

#### Assets

#### **Early Career Faculty:**

There is a minimal number of NSF Early Career Faculty in this research area. There were two awardees with an associated topic from 2016-21.

#### **Major Centers/Specialized Equipment:**

- Dartmouth Center for Quantitative Biology (NIH COBRE)
- Geisel School Dept of Biomedical Data Science (Dartmouth)
- The Hubbard Center for Genome Studies (UNH)
- Institute for Quantitative Biomedical Sciences (iQBS) (Dartmouth)
- Dartmouth Center for Clinical and Translational Science (Dartmouth)

#### **Notable Industry Presence in NH:**

 Focus Proteomics - Contract service organization specializing in 2D gel electrophoresis and protein characterization (Hudson)

#### **Research Funding Outlook**

#### **Key Driver(s):**

- Infectious Disease Modeling, Prediction, and Forecasting is one of the four R&D focus areas linked to public health and innovation for the federal FY2022 budget.
- Data Science is one of the cross-cutting themes in the "NIH 2021-2025 Strategic Plan." As a result, "NIH is conducting multiple initiatives to build platforms, workspaces, and provide tools and applications to researchers to securely store, analyze, and share data assets. Two examples include the Genomic Data Science Analysis, Visualization, and Informatics Lab-space and the Cancer Research Data Commons."

#### **NSF FY22 Budget Request:**

- A portion of the Biotechnology request (\$324.61M) will focus on research and infrastructure for bioinformatics, computational biology, data analytics, structural biology, biophysics.
- Artificial Intelligence (\$734.41M) for fundamental research in this area.



#### FY22 President's Budget:

- FY 2022 budget request contains health IT-related investments, such as the modernization of public health data at CDC.
- The FY 2022 budget request for The Centers for Disease Control and Prevention (CDC) is \$8.7B, an increase of \$1.6B billion over FY 2021 and the largest increase for CDC in nearly 20 years. Modernizing public health data collection in the US will be a key priority.

### **5.4 Environmental Remote Sensing**

The area is focused on the application of sensing, measuring, and controls technologies for the environmental sciences. This interdisciplinary field integrates physical, biological, and information sciences.

Environmental remote sensing is an established research area in NH with work occurring at UNH and Dartmouth in a variety of departments and fields and across a range of applications including monitoring of oceans, earth, and space. However, this research activity in New Hampshire has not translated into significant industry activity.

New Hampshire has core academic research fields associated with environmental remote sensing.

#### Strengths

New Hampshire has core academic research fields associated with environmental remote sensing. This includes research activities at the UNH Institute for the Study of Earth, Oceans, and Space, and co-authored research by UNH faculty with major federal contractors, like Science Systems and Applications, Inc. (SSAI) and companies such as Google. In FY 2019, UNH research expenditures in geo-, atmospheric, and ocean sciences made up the second largest research and development field (\$48.1M). This was the lowest research field at Dartmouth (\$4.4M).

Research strengths include:

#### **Ocean science:**

- Robotics
- Spatial-temporal data
- Arctic initiative
- Ocean carbon cycle monitoring, mercury as a cycling issue related to organic carbon
- Interface between terrestrial and aquatic/landocean

#### **Forest Science:**

- Forest ecosystems
- Climate change
- Forest management
- Biometrics
- Soil biogeochemistry
- LiDAR, wildlife management



#### **Freshwater Science:**

- Droughts and floods
- Climate change
- Major infrastructural impacts
- Availability of water resources and management
- Water quality related to land-use change, algal blooms
- Robotics
- Stream bank erosion
- Species impact/geomorphology

#### Weaknesses

A gap for New Hampshire is the lack of research expertise in environmental remote sensing focused on solutions. Most of NH's capacity in environmental remote sensing involves problem definition to accurately describe and monitor climate, forests, oceanic conditions. However, the greater economic and social benefit that could come from this area is in the development of mitigation strategies. In FY 2019, research expenditures in geo-, atmospheric, and ocean sciences at Dartmouth were the lowest among the top 10 science and engineering research fields there (\$4.4M).

#### **Opportunities**

UNH and Dartmouth have research expertise and remote sensing tools that when combined with ocean science, forest science, and freshwater science specialties provide distinctive capabilities for climate change research. Within climate change research there are research opportunities related to permafrost collapse and changing winters.

Specific topics include:

- Impact on ocean carbon cycle
- Hydrology
- · Forest ecosystems and vegetation change
- Soil microbial activity
- Robotics and drone-based LiDAR
- Spatial data
- Machine learning

Most of NH's capacity in environmental remote sensing involves problem definition to accurately describe and monitor climate, forests, oceanic conditions.



#### **External Conditions**

Relative to Canada and Europe, the U.S does not currently have a nationally coordinated climate change policy. This hampers industry and research development in the U.S. (with the exception of the weather and space industries) and could impact the growth of environmental remote sensing for climate change research.

#### Assets

#### **Early Career Faculty:**

Environmental Remote Sensing is a research area with a minimal number of NSF Early Career Faculty. There were two awardees with an associated topic in this area from 2016-21.

#### **Major Centers/Specialized Equipment:**

- Institute for the Study of Earth, Oceans, and Space (UNH)
- UNH Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC)
- The Dartmouth Toxic Metals Superfund Research Program
- Super Dual Auroral Radar Network (Dartmouth)
- UNH Center for Infrastructure Resilience to Climate (UCIRC)
- Ocean Process Analysis Lab (UNH)

#### **Notable Industry Presence in NH:**

Normandeau Associates, Inc. - An environmental consulting firm that provides ecological, environmental, and natural resources management services including airborne and satellite remote sensing, tracking and environmental management solutions (Bedford)

#### **Research Funding Outlook**

#### **Key Driver(s):**

• The American Jobs Plan (March 2021) includes "\$35 billion for climate science, innovation, and R&D that addresses climate change and promotes clean energy technology and jobs. This includes launching an Advanced Research Projects Agency-Climate (ARPA-C) to develop new methods for reducing emissions, building climate resilience, and expanding across-the-board funding for climate research. An additional \$5 billion is proposed for other climate- focused research".<sup>37</sup>

#### **NSF FY22 Budget Request:**

• U.S. Global Change Research Program (USGCRP) requests \$762.M for research on natural and human components of the Earth System and global climate.

#### FY22 President's Budget:

Requested agency funding associated with climate change includes<sup>38</sup>:

- Department of Energy (DOE) request of \$200M to establish the Advanced Research Projects Agency-Climate (ARPA-C)
- Department of Commerce (DOC) request of \$6.9B for the National Oceanic and Atmospheric Administration (NOAA), a \$1.4B increase over FY 2021, which includes \$800M to expand climate research investments

<sup>37</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/Bidens-American-Jobs-Plan-Proposes-2-Trillion-in-New-Federal-Spending/4851?researchTypeld=1&researchMarket=

<sup>38</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/FY-2022-Presidents-Budget-Request--GovWin-FMAs-First-Take/5969?researchTypeld=1&researchMarket=



### **5.5 System Networks**

This area is focused on the integration of computer devices, software, and associated peripherals into an interconnected system or network to foster communications, information exchange, or data transfer.

System networks is an established area in New Hampshire with research activity in networking and cybersecurity. Industry involvement includes businesses focused on networking as well as startups that have received venture capital investments to develop networking technologies.

#### Strengths

In FY 2019, the UNH's top engineering research and development field (\$9.2M) was electrical, electronics, and communication engineering, which represents core systems network research. One of the top three patenting categories in NH is digital communication, reflecting the pipeline of innovations that exist for development in this area. From an industry standpoint, New Hampshire has a subset of tech companies focused on cellular network innovation to improve deployment and meet data demands. From 2016-2020, four New Hampshire networking companies received venture capital investments including Collision Communications, Parallel Wireless, and Senet.

Research strengths to build upon include:

- Cybersecurity: Technologies and measures for protecting networks, devices, and data; both hardware and software (includes artificial intelligence (AI) and machine learning)
- Interoperability: The ability of a system to work with or use the parts or equipment of another system; applications in sensor networks, Internet of Things (IoT), cybersecurity

#### Weaknesses

A gap for New Hampshire is the small amount of computer science research and development (R&D) at UNH (\$0.9M in FY19) relative to its total R&D activity of \$149M and compared Dartmouth.<sup>39</sup> This gap in computer science R&D at UNH is critical because computer software is an important part of system networks, which could limit the options for UNH to expand in this area. System

 networks is
 an established
 area in New
 Hampshire
 with research
 activity in
 networking and
 cybersecurity.



#### **Opportunities**

Information technology convergence across all industry sectors is driving demand. New Hampshire has an opportunity to leverage its innovative companies and university research capabilities to build out a cluster in system networks. A potential research theme is smart and secure materials focused on cybersecurity, interoperability, process technologies, and advanced materials.

#### **External Conditions**

There is external pressure from competitor regions which are investing in 5G and other network innovations, along with cybersecurity and interoperability.

#### Assets

#### **Early Career Faculty:**

The system networks research area has a minimal number of NSF Early Career Faculty. There were two awardees with an associated topic in this area from 2016-21

Major Centers/Specialized Equipment:

- UNH Connectivity Center
- UNH Interoperability Laboratory
- UNH Research Computing Center
- The Institute for Security, Technology, and Society (Dartmouth)
- The Center for Cybersecurity Leadership, Education, and Outreach (UNH)

#### **Notable Industry Presence in NH:**

- Oracle Dyn: Domain name server provider for websites (Manchester)
- Extreme Networks: Provider of network solutions and software for Information Technology departments in various industries (Salem)
- Optiv: Provider of Internet and cybersecurity solutions (Portsmouth)

#### **Research Funding Outlook**

#### **Key Driver(s):**

 Blockchain, Unmanned Delivery Systems and Internet of Things (IoT) are three of the seven emerging technologies included in the America COMPETES (Competitiveness of a More Productive Emerging Tech Economy) Act to strengthen the U.S. competitiveness.<sup>40</sup>

#### **NSF FY22 Budget Request:**

- Advanced Wireless (\$166.61M) for fundamental research in the advanced wireless area
- Secure and Trustworthy Cyberspace (SaTC) (\$153M) for cybersecurity and privacy research

#### **FY22 President's Budget:**

 Army Defensive Cyber Operations Software Prototype Development proposed FY 2022 budget for research, development, test, and evaluation (RDT&E) includes \$5.5M for universities, industry, federal laboratories, or others to support development engineering, integration, testing, training development, and program management to complete the last capability within their current IT box, CD3.<sup>41</sup>

<sup>40</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/The-American-COM-PETE-Act/4812?researchTypeId=1&researchMarket=

<sup>41</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/Budget-Analysis-Army-Programs-Spending-on-Cybersecurity-and-Warfare-in-FY-2022/6144?researchType-Id=1&researchMarket=

## 5.6 Data Analytics, Artificial Intelligence, and Machine Learning

This area involves the use of techniques and processes for collecting, analyzing, and storing data including automation, simulation, and software algorithms.

Data analytics, artificial intelligence, and machine learning are an established research area with activity across a variety of associated subfields at both Dartmouth and UNH. This industry is emerging in New Hampshire with an increasing number of businesses offering related products and services.

#### Strengths

UNH has an active artificial intelligence (AI), machine learning, and robotics research cluster within computer science. At Dartmouth, the leading research and development subfield is computer science (\$15.8M in FY19). The industry sector is large, diverse, and growing, employing 37,000-44,000 people. Sixty-one percent of companies in this sector have fewer than 50 employees.

Research strengths to build upon include:

- Artificial Intelligence: Computers and machines that mimic the problem-solving and decision-making capabilities of humans, e.g., speech recognition, chatbots, recommendation engines.
- Machine Learning: Algorithmic applications of AI that give systems the ability to learn and improve without ample human input.
- Text Data Mining: Analysis of vast collections of unstructured text into a structured format to identify meaningful patterns and new insights. Machine learning can be applied to text mining.
- Natural Language Processing: A subfield of linguistics and AI that enables computers to understand text and verbal language in much the same way humans can. Applications include spam detection, Google Translate, Siri/Alexa, and sentiment analysis.

#### Weaknesses

A major challenge for growth in New Hampshire's data analytics, artificial intelligence, and machine learning area is that computer science research and development (R&D) at UNH is small (\$0.9M in FY19) relative to its total R&D activity (\$149M) and compared Dartmouth, which had \$15.8M of computer science R&D in FY19.

#### Opportunities

Information technology convergence across all industry sectors has created big data sets and opportunities to apply artificial intelligence (AI), machine learning (ML), and better data analytics in New Hampshire. The highest near-term growth opportunities rated by the NH Tech Alliance member survey are:

- Software and application development
- Advanced manufacturing
- Energy technology/cleantech
- Cybersecurity

#### **External Conditions**

There is external pressure from competitor regions that are investing in internet of things (IoT) and robotics innovations and applications

#### Assets

#### **Early Career Faculty:**

This research area has an established number of NSF Early Career Faculty from New Hampshire. There were five awardees with associated topics in this area from 2016-21.

Major Centers/Specialized Equipment:

- The Neukom Institute for Computational Science (Dartmouth)
- High Performance Computing Core (UNH and Dartmouth)

The
 Department
 of Defense's
 FY22 budget
 request for
 Artificial
 intelligence
 is \$874M \$

#### **Notable Industry Presence in NH:**

- Athenium Analytics: Software solutions provider specializing in quality assurance for the insurance industry. In 2018 they merged with Weather Analytics, which uses weather/atmospheric data and computer science to solve business challenges. (Dover)
- Fidelity Investments: A financial advisory and investment company that is a large user of data and data analytics. (Headquartered in Merrimack)
- Bottomline Technologies: Financial technology company that provides software as a service (SaaS) to banking, large payment networks, and corporate clients. (Portsmouth)

#### **Research Funding Outlook**

#### **Key Driver(s):**

- Artificial intelligence (AI) is one of the seven emerging technologies included in the America COMPETES Act to strengthen US competitiveness<sup>42</sup>
- Federal spending on artificial intelligence increased to \$1B in FY2020, up 50% from FY2018 with the majority of this spending for artificial intelligence (AI)/machine learning (ML) in research and development<sup>43</sup>
- Until recently, R&D work at agencies with scientific missions such as NASA and the Department of Energy dominated federal investment in AI/ML, but is now growing at agencies without a primarily scientific mission, such as the departments of Justice and Transportation<sup>44</sup>

#### **NSF FY22 Budget Request:**

Artificial Intelligence for foundational research (\$734.41M)

#### **FY22 President's Budget:**

- The Department of Defense's FY22 budget request for Artificial intelligence is \$874M
- Department of Defense funding is \$2.3B, which includes artificial intelligence/machine learning, and other areas such as materials, and quantum science<sup>45</sup>

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45 Deltek - FY 2022 President's Budget Request – GovWin FMA's First Take | GovWin IQ

 $<sup>42 \</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/The-American-COMPETE-Act/4812?researchTypeId=1&researchMarket=1$ 

 $<sup>43 \</sup> Deltek - https://iq.govwin.com/neo/marketAnalysis/view/Federal-Artificial-Intelligence-Landscape-2022/53229? researchTypeId=2& researchMarket=2022/53229? researchTypeId=2& researchMarket=2& researchMarket=2022/53229? researchTypeId=2& researchMarket=2& researchMarke$ 

## **5.7 Advanced Materials**

This area focuses on the development, usage, and integration of a variety of basic materials into more complex material structures to provide solutions for various applications ranging from bioscience, energy, chemistry, metallurgy, and polymers to end user applications involving building or transportation infrastructure (including buildings and bridges) and consumer and industrial products.

Advanced materials in New Hampshire is an established field with research across various areas including metals and plastics. Additionally, there is a great deal of industry activity in this area with established, small to mid-sized companies in New Hampshire focused on developing a range of advanced materials for applications in the marketplace.

#### Strengths

New Hampshire has expanded its research in advanced materials in recent years. The current NSF EPSCoR supported New Hampshire Center for Multiscale Modeling and Manufacturing of Biomaterials (NH BioMade) takes a "make, model, measure' approach to biomaterials for use in implants, trauma fixation, bio-compatible sensors and tissue scaffolding. University-Industry partnerships in this area are supported by academic centers such as the UNH John Olson Center for Advanced Manufacturing. Advanced materials companies in New Hampshire primarily manufacture metals, fabricated metals, plastics, and rubber products and employ 19,685 people. This figure does not include New Hampshire-based companies specializing in cutting systems for advanced materials, like Hypertherm, and Thermacut.

Research strengths to build upon include:

- Mechanical behavior of structural materials
- Properties of functional materials
- Biomaterials
- Energy materials

Advanced materials in New Hampshire is an established field with research across various areas including metals and plastics.

#### Weaknesses

One of the major gaps is that research and development (R&D) activity is very small at UNH and Dartmouth in two research fields associated with advanced materials. In FY19, UNH's Metallurgical and Materials Engineering R&D was \$0.4M and Materials Science was \$0.2M while Dartmouth's Metallurgical and Materials Engineering and Materials Science R&D was \$0.0M. Chemistry R&D at UNH was much lower at \$1.6M as compared to Dartmouth at \$8.1M for the same period.

#### **Opportunities**

End users are seeking materials that are lightweight, sustainable, intelligent, or enhanced with a variety of other characteristics. There is also interest in new processes for creating them, such as additive manufacturing. New Hampshire can build on the state's recent successes in this area by leveraging federal funding opportunities focused on advanced materials by the Department of Defense (DOD), Department of Energy (DOE), National Science Foundation (NSF), and National Institutes of Health (NIH).

Potential research themes for this area include:

- Smart and secure materials
- Materials for energy generation and energy storage
- Materials for quantum computing

#### **External Conditions**

There is external pressure from competitor regions that have larger research universities working with end users and advanced materials companies.

#### Assets

#### **Early Career Faculty:**

Advanced Materials is a research area with an emerging number of NSF Early Career Faculty from New Hampshire. There were four awardees with associated topics in this area from 2016-21.

#### **Major Centers/Specialized Equipment:**

- John Olson Center for Advanced Manufacturing (UNH)
- Regional Center for Advanced Manufacturing (Keene State College)
- Center for Advanced Materials and Manufacturing Innovation (UNH)
- Advanced Technology and Academic Center (Great Bay Community College)

#### **Notable Industry Presence in NH:**

- Allegro MicroSystems: Sensing and power semiconductor technologies (Manchester)
- NH Ball Bearings: Ball bearing manufacturer for aerospace, medical, and tech industries. (Peterborough)
- Hypertherm, Inc.: Provider of advanced cutting solutions (Hanover)
- Albany International Corp.: Manufacturer of materials, fabrics, and composite components for the aerospace industry (Rochester)
- GE Aviation: Technology machining and manufacturing operations supporting GE's aircraft engine business (Hooksett)
- Ruger Firearms: Leading manufacturer of firearms for the commercial sporting market (Newport)

#### **Research Funding Outlook**

#### **Key Driver(s):**

Advanced Materials (specifically new and advanced materials such as synthetically derived or enhanced natural properties) and 3D printing are two of the seven emerging technologies included in the America COMPETES Act to strengthen US competitiveness<sup>46</sup>

 Advanced Materials is

 a research
 area with an
 emerging
 number of
 NSF Early
 Career Faculty
 from New
 Hampshire.



#### **NSF FY22 Budget Request:**

- Advanced Manufacturing (\$418.51M) for advanced manufacturing research
- Part of Biotechnology (a portion of \$324.61M) to include research and infrastructure for Advanced Materials such as biomaterials, and tissue engineering.

#### FY22 President's Budget:

Department of Defense (DoD) agencies requested \$2.3B in basic research funding with novel engineered materials as one of the areas of focus.<sup>47</sup>

## 5.8 Computer and Electronic Components

This area involves the development, application, operation and integration of computer and electronics components including basic electronics (resistors, switches), power electronics, measurement instruments, and optoelectronics for devices such as electronic circuits, computer hardware, quantum computing devices, industrial controls, and electrical appliances.

Computer and electronics components is an established area in NH from a research and industry standpoint. UNH and Dartmouth research, patents, and publications address associated fields such as optics, electrical engineering, and power engineering. The state also has a diverse industry with a large segment of employment in manufacturing computer and electronic components.

#### Strengths

There is multi-institutional involvement with several areas of expertise across the academic research field for the computer and electronic components area in New Hampshire. Dartmouth has expertise in semiconductors and power electronics and both UNH and Dartmouth have strengths in optics and sensors. New Hampshire has demonstrated active innovation activity in patent categories associated with computer and electronic components. Computer technology is New Hampshire's fourth largest patenting category (42.8 patents/year, 2016-20). In other relevant patent categories, New Hampshire inventors also produced 20 optics patents/year and 17 semiconductor patents/ year during the same period. Computer and electronic components are New Hampshire's largest manufacturing segment (16,483 employees; 2.7% CAGR, 2014-19).

Areas of strengths for the computer and electronic components area for New Hampshire to expand are the following:

- Semiconductors and power electronics
- Energy storage
- Materials for energy applications

#### Weaknesses

One of the gaps for New Hampshire is that there have been minimal physical sciences publications with corporate co-authors (2019-20) in fields associated with computer and electronic components. Dartmouth had 16 papers in Electronics & Electrical Engineering and Optics, while UNH had a smaller number of papers with corporate co-authors in Computer Technology.

#### **Opportunities**

New Hampshire could leverage national security interest in onshoring more electronics and semiconductor manufacturing in the U.S. Increased demand for power electronics for electric vehicles and industrial automation also presents an opportunity for growth in this area.

#### **External Conditions**

The concentration of global electronics manufacturing activity is concentrated in East Asia and offshoring is likely to continue because of lower production costs and high global demand. Additionally, governments in East Asian and European countries are making significant investments in associated areas including power electronics, semiconductors, and related research and innovation activity.



#### Assets

#### **Early Career Faculty:**

Computer and Electronic Components is a research area with a minimal number of NSF Early Career Faculty from New Hampshire. There was only one awardee with an associated topic in this area from 2016-21.

Major Centers/Specialized Equipment:

- Scalable Energy and Nanomaterial Electronics Lab (Dartmouth)
- The Power Management Integration Center (Dartmouth)
- Dartmouth Microengineering Laboratory
- Sustainable Product Design and Innovation Program (Keene State College)

#### **Notable Industry Presence in NH:**

- BAE Systems Electronic Systems: Produces commercial and defense electronics (headquartered in Nashua)
- Optics industry cluster: Including Moore Nanotechnology Systems, Janos Technology, and Corning Advanced Materials (Keene and surrounding area)
- Osram Sylvania: Electrical manufacturer of lighting products for auto, aviation, and electrical industries (Hillsborough)
- Texas Instruments: Worldwide semiconductor manufacturing and design company (Manchester)
- Raymarine: Producer of marine electronics for the recreational boating and light commercial marine markets (Nashua)

#### **Research Funding Outlook**

#### **Key Driver(s):**

 Quantum computing is one of the seven emerging technologies included the America COMPETES Act to strengthen the U.S. competitiveness<sup>48</sup>

#### **Recent Initiatives**<sup>49</sup>:

- DOE provided \$30M in March 2021 to advance understanding of Quantum Information Science (QIS) capabilities in climate change and national security
- The Air Force issued 17 QIS grants in December 2020 to bolster understanding of particle physics in computing

Computer and Electronic
Components
is a research
area with a
minimal
number of
NSF Early
Career Faculty
from New
Hampshire.



• NASA established the Quantum Artificial Intelligence Laboratory at the Ames Research Center to assess quantum potential against agency computational challenges in aeronautics, Earth and space sciences, and space exploration missions

#### **NSF FY22 Budget Request:**

Quantum Information Science (QIS) (\$260M) for research in the quantum phenomena, such as information processing

#### FY22 President's Budget<sup>50</sup>:

- National Science Foundation requests \$260M to advance seven areas of quantum information science research
- Department of Commerce/National Institute of Standards and Technology (NIST) requests:
- \$206M for fundamental measurement, quantum science, and measurement dissemination
- \$62M for quantum information science, engineering, and metrology
- Department of Energy/Office of Science requests \$108M to continue support for quantum information science, research centers, establishing a dedicated quantum network, and advancing research in quantum algorithms, applications, and testbeds
- Department of Defense: requests \$2.3B for fundamental research in microelectronics

#### 5.9 Renewable Energy

This area focuses on the generation, transmission, and distribution of energy from renewable (or naturally replenishing) sources including biomass, hydropower, geothermal, wind, and solar.

In New Hampshire, renewable energy is an emerging research field with work primarily occurring in transmission and distribution subfields like materials and power engineering. There is a small established base of renewable energy companies consisting of producers and components developers/manufacturers for renewable energy power generators. The state has had minimal venture capital activity in this area during the last five years.

#### Strengths

New Hampshire has research strengths in power electronics, energy storage, and materials. Collaborative research activity with industry is facilitated by the Power Management Integration Center at Dartmouth (an Industry-University Collaborative Research Center (IUCRC) funded by the National Science Foundation).

New Hampshire has a small renewable energy industry base bolstered by its renewable energy portfolio standard, tax credits, and other financial incentives for renewable energy adoption. The renewable energy industry in New Hampshire also has several companies focused on developing or manufacturing various components and devices for the solar manufacturing supply chain (e.g., inverters, racks, electrical BOS, and batteries).

Research strengths for New Hampshire to build on are:

- Energy storage—area of university research strength and key to reducing the cost of renewable energy adoption
- Sustainable systems—leverages Dartmouth Irving Institute for Energy and Society; connects many research areas/threads; collaborative network of faculty and industry members interested in addressing this challenge; need for improved understanding of system integration and potential large-scale changes in infrastructure
- Power generation and delivery—strong New Hampshire industry sector; world-class research capabilities at both the component level and the system level; leverages Dartmouth Power Management Integration Center research



#### Weaknesses

The availability of nuclear and hydroelectric energy has dampened demand for other clean energy sources. According to the U.S. Energy Information Administration (EIA), 61% of New Hampshire's electricity comes from nuclear energy while only 17% comes from renewable energy, primarily hydroelectric and biomass, but also wind and solar. Another weakness is the lack of venture capital investment. Only one New Hampshire energy company (Nanoscale Components) has received venture capital investment in the past five years.

#### **Opportunities**

New Hampshire could leverage federal investments in renewable energy and state and regional investment in offshore wind to expand research and industry.

#### **External Conditions**

The US renewable energy policy does not provide strong demand/pull conditions for renewable energy adoption. Therefore, the price of electricity from natural gas and other sources is low in comparison to renewable energy sources.

#### Assets

#### **Early Career Faculty:**

Renewable Energy is a research area with a minimal number of NSF Early Career Faculty from New Hampshire. There were two awardees with an associated topic in this area from 2016-21.

- 52 Deltek https://iq.govwin.com/neo/marketAnalysis/view/Bidens-American-Jobs-Plan-Proposes-2-Trillion-in-New-Federal-Spending/4851?researchType-Id=1&researchMarket=
- 53 Deltek https://iq.govwin.com/neo/marketAnalysis/view/Federal-Quantum-RD-Accelerates/6050?researchTypeId=1&researchMarket=
- 54 Deltek https://iq.govwin.com/neo/marketAnalysis/view/FY-2022-Presidents-Budget-Request--GovWin-FMAs-First-Take/5969?researchTypeld=1&researchMarket=

#### **Major Centers/Specialized Equipment:**

- The Power Management Integration Center (Dartmouth)
- Arthur L Irving Institute for Energy and Society: One focus area is on transformative energy systems to produce sustainable power such as hydrogen fuel cells using renewable energy (Dartmouth)
- Center for Ocean Renewable Energy (UNH)

#### **Notable Industry Presence in NH:**

 Mascoma: One of Lallemand's research and development centers,<sup>51</sup> focused primarily on new industrial biotechnology products including innovative microorganism products used in bioethanol generation (Lebanon)

#### **Research Funding Outlook**

#### **Key Driver(s):**

The American Jobs Plan (March 2021) includes \$15 billion for demonstration projects for climate R&D priorities including utility-scale energy storage, carbon capture and storage, hydrogen, advanced nuclear, rare earth element separations, floating offshore wind, biofuel/bioproducts, quantum computing, and electric vehicles, as well as strengthening US technological leadership in these areas in global markets". <sup>52</sup>

#### **NSF FY22 Budget Request:**

Clean Energy Technology (CET) (\$440M) and cleanenergy investments in high-risk, high-reward ideas

#### FY22 President's Budget<sup>53</sup>:

Department of Energy has requested \$4.7B of \$46B FY22 budget request for the Office of Energy Efficiency and Renewable Energy (EERE) to achieve carbon-pollution free electricity by 2035 and net-zero emissions by 2050.<sup>54</sup>

<sup>51</sup> Further details regarding Mascoma at https://www.lallemand.com/research/ research-centers/

# 6 Relative Assessment of Assets & Potential Funding to New Hampshire's Research Areas

The relative assessment in Table 2 provides a snapshot of major assets and potential funding for each of nine research areas to help prioritize and gauge which resources are currently available, and which may need to be developed in the future. It is based on information presented in the previous NH Targeted Research Areas section of this report.

#### Table 2: Relative Assessment of Assets for New Hampshire Research Areas

	CATEGORY				
	Early Career Faculty	Major Facilities/ Specialized Equipment	Industry Presence	4 NSF FY22 Funding Outlook	
RESEARCH AREA	<ul> <li>No Early Career Faculty</li> <li>Minimal: 1-2 Faculty</li> <li>Emerging: 3-4 Faculty</li> <li>Established: 5+ Faculty</li> </ul>	<ul> <li>No Major Facilities/ Spec. Equip.</li> <li>Minimal: 1-2 Facilities/Equip.</li> <li>Emerging: 3-4 Facilities</li> <li>Established: 5+ Facilities</li> </ul>	<ul> <li>No Presence</li> <li>Minimal: No growing employment and/or few notable employers</li> <li>Emerging: Growing employment and/or some notable employers</li> <li>Established: High employment and/or multiple notable employers</li> </ul>	<ul> <li>No NSF Funding</li> <li>Minimal: &lt;\$350 M</li> <li>Emerging: \$351-\$700 M</li> <li>Established: \$700 M+</li> </ul>	
Biotherapeutics	$\bullet$			$\bullet$	
MedTech				$\bullet$	
QuantitativeLife Sciences & Bioinformatics					
Environmental Remote Sensing					
System Networks	$\bullet$			$\bullet$	
Data Analytics, AI & Machine Learning		$\bullet$			
Advanced Materials					
Computer and Electronic Components	lacksquare			lacksquare	
Renewable Energy					

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# **7** Goals, Strategies and Metrics

The 2021 New Hampshire University Research and Industry Plan goals focus on the important role of university research and development in growing NH's innovation economy. They are informed by and align with New Hampshire's target industry sectors and economic development strategy.

By 2026:

- Expand R&D activities and expenditures in target research areas by 10%
- Grow NH's skilled workforce ready population with a focus on underrepresented groups in STEM by 5%
- Increase Infrastructure and capacity needed to expand R&D in targeted research areas by 10%

New Hampshire's government, industry, higher education institutions, and non-profits all play a role in advancing these state-level goals. However, the proposed strategies included in Table 3 are focused on actions within the purview of NH's higher education institutions and NH EPSCOR. Target percentages will be measured using the indicator metrics included for each goal.

#### GOAL 1

Increase R&D activities (projects, publications) and expenditures in target research areas by 10% by 2026

#### Strategies

- Pursue large grant opportunities
- Prioritize faculty hires
- Increase industry-sponsored research and licensing
- Create collaborative partnerships with stakeholders (primarily undergraduate institutions, state agencies, industry, non-profits)
- Create comprehensive portal of SBIR/STTR proposal technical support across NH
- Fill gaps in SBIR/STTR proposal development funding support (Phase 0 funds, Phase 1 and 2 match)
- Advocate for state supported fund to contribute required match support for large federal grants

- State R&D expenditures
- Growth in faculty/researcher community
- Success of early-career researchers
- Industry sponsored research
- Funded projects
- New or expanded infrastructure
- Increase in SBIR/STTR proposals and projects
- Publications
- New or expanded partnerships
- State support to leverage federal research funding

GOAL 2

Increase NH's skilled workforce-ready population with a focus on underrepresented groups in STEM by 5% growth by 2026

#### Strategies

- Increase internships and applied research experiences, especially for underrepresented students
- Expand universal articulation agreements between USNH institutions and the community colleges focused on STEM disciplines
- Increase awareness and use of existing Universal Pathways (universal articulations/course equivalencies) with critical stakeholders (faculty, staff, parents, teachers, guidance counselors and students)
- Increase transfer student population through recruitment onboarding, ongoing support, tracking metrics, and scholarships
- Strengthen partnerships between NH's higher education institutions and industry to align workforce development efforts
- Leverage partnerships between NH's higher education institutions and industry to co-develop curriculum and programs that address STEM workforce needs
- Increase awareness and access to professional degrees, certifications, and badges that align with STEM workforce skillset needs

- Two-year and four-year STEM degrees conferred
- MS/PhD degrees conferred
- Research experiences and internships
- Companies participating in internship programs
- Demographics of students in STEM programs, internships, and research experiences
- Number of transfer students in STEM programs at four-year institutions
- Success of transfer students in STEM programs
- Curricula, badges, certificates, degree programs aligned with workforce/skillset needs
- New or strengthened partnerships between higher education institutions and industry focused on alignment of workforce development efforts

GOAL 3

Increase infrastructure and capacity needed to expand R&D in targeted research areas by 10% by 2026. For the purposes of this plan, infrastructure includes the talent, centers, projects, physical spaces, partnerships, equipment, and instrumentation needed to grow R&D in the targeted areas

#### Strategies

- Increase grant funding for the purchase of new equipment and instrumentation
- Expand usage of equipment and instrumentation across the state and region
- Provide seed funding and other supports to build multi-stakeholder (faculty, industry, state agencies, non-profits) collaborative project teams
- Prioritize the development of physical spaces and centers focused on targeted research areas
- Prioritize cluster hires
- Partner with industry and state government to leverage support for infrastructure

- Equipment and instrumentation supported by state and federally funded grants aligned to R&D and workforce goals
- Shared use of core facilities
- New or strengthened partnerships between academic institutions, industry, state government that support growth in targeted research areas
- Number of:
  - Publications
  - Proposals submitted
  - Funded projects
  - Equipment and instrumentation acquired or included in proposals and funded projects
  - · Centers developed or under development
  - Physical spaces allocated or created
  - Faculty hires completed or included in funded projects
  - Collaborative teams developed
  - State or federal support for new or expanded infrastructure

8 New Hampshire Research and Industry Council (NHRIC) Members

Name	Title	Institution/Organization		
Government				
Sen. Jay Kahn	Senator, District 10	NH Senate		
Dave Pease	Program Manager, NH PTAC	NH Dept. of Business and Economic Affairs		
		dustry		
Michael Behrmann	Director, Offshore Wind Industry Development	NH Business Finance Authority		
Dave Cuzzi	President	Prospect Hill Strategies		
Len Chaloux	President Emeritus & Co-Founder	Moore Nanotechnology Systems, LLC		
Vice Chair, Liz Gray	State Director	NH Small Business Development Center		
Pam Hall	CEO and Board Chair	Normandeau Associates		
Aimee Hodge	Vice President, Operations	Lyophilization Services of New England		
Jay Hoying	Chief Scientific Officer	Advanced Solutions Life Sciences		
Jeff McIver II	Manager, Consumer Products	Consolidated Communications		
Alexander Titus	Strategy and Innovation Lead, Healthcare and Life Sciences for the Global Public Sector Founder	Google, Inc. Bioeconomy.XYZ		
	Educatio			
Brian Bicknell	President	Manchester Community College		
Sr. Paula Marie Buley	President	Rivier University		
Chair, Kevin Carroll	Adjunct Professor	UNH Franklin Pierce School of Law; Grossman, Tucker, Perreault & Pfleger, LLC		
Cyndee Gruden	Dean	College of Engineering & Physical Sciences, University of New Hampshire		
Marian McCord	Senior Vice Provost for Research, Economic Engagement and Outreach	University of New Hampshire		
Dean Madden	Vice Provost for Research	Dartmouth College		
Lisa Thorne	Communications Director	University System of NH		
At Large				
Cindy Conde	Chair, BioTech/ MedTech Cluster	NH Tech Alliance		
Eric Feldborg	Education Consultant	NH Learning Initiative		
Terrance Large	Retired	Eversource Energy		
Justin Slattery	Executive Director	Belknap Cty. Economic Development Council		