



PENN IUR WHITE PAPER SERIES ON SUSTAINABLE URBAN DEVELOPMENT

## **From Science Parks to Innovation Districts**

### **Research Facility Development in Legacy Cities on the Northeast Corridor**

Working Paper 2015/008

August 2015

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## Introduction

Research and development (R&D) drives advanced economies worldwide. It is this that provides the foundation for the new knowledge, products, and processes that, in turn, become new industries, create jobs and serve as the source of economic growth. Key areas for R&D are in what is called the knowledge and technology industries (KTI) that consist of high technology manufacturing (e.g. aircraft, spacecraft, pharmaceuticals) and knowledge-intensive services (commercial business, financial and communication services).

KTI, which account for 27% of the worldwide Gross Domestic Product (GDP), are extremely important to the United States, in particular, representing 40% of the U.S. GDP. In fact, the U.S is the world's largest KTI producer – contributing 27% of the total HT manufacturing and 32% of the KI services.<sup>1</sup> In order to grow and maintain these positions, the United States, like its peers in Europe and Asia who are also large contributors, has built an extensive R&D infrastructure composed of three strong players: the private sector, the public sector and universities.

In terms of expenditures and numbers of employees, the private sector dominates the R&D enterprise, but the university sector, largely funded by the US government, is also an important component both directly and indirectly. It leads in direct basic research often partnering with the private sector. And the presence of a strong research university is often a deciding factor for research-intensive corporations making regional location decisions dependent on having an educated workforce.

Additionally, with regard to local economic development, these universities have become increasingly important to their host cities. Anchored by their real estate holdings, missions and histories, they are also large, stable employers. They serve as a new kind of “factory” whose product is new, often patentable, knowledge paid for with external (federal) funds. More recently, they have begun serving as sources of invention and re-invention as they meet their spatial needs for laboratories on and off campus. Their building programs, again largely financed by federal research funding, or donor support garnered to attract more federal funding, are often directed to expanding the campus footprint, creating separate technology parks or innovation districts, or adapting former industrial space.

This paper explores the spatial aspects of university-led R&D in Legacy Cities in the Northeast Corridor. It has four parts. The first part provides an overview of the U.S. R&D enterprise, describing the position and character of university R&D. The second part reviews of university-based research in technology parks, a spatial arrangement developed in the 1960s that is still evolving. The third part offers a case study of Philadelphia and the University of Pennsylvania (Penn), representing several models of spatial development of university-led R&D spanning from the 1960s to the present. The fourth part discusses other universities and their evolving approaches to accommodating research in their neighborhoods with examples from Boston/Cambridge (Harvard), New York (Columbia and Cornell) and Baltimore (Johns Hopkins).

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<sup>1</sup> National Science Foundation, *Science and Engineering Indicators 2014*  
<http://www.nsf.gov/statistics/seind14/content/overview/overview.pdf>

**PART 1. OVERVIEW: RESEARCH AND DEVELOPMENT IN THE UNITED STATES**

In 2012, the United States spent a total of \$452 billion or 2.9% of its GDP on research and development.<sup>2</sup> The country ranks eighth in R&D expenditures as a percentage of GDP after Israel (4.4%), Finland (4%), Korea (3.8%), Japan (3.4%), Sweden (3.4%), Denmark (3%), and Switzerland (3%) in R&D expenditures. Of note, is the recent re-classification of R&D expenditures in the GDP calculations, counting them as investments rather than costs as was formerly done, a choice that has the effect of accounting for their contributions to the national product but slightly lowers the GDP-to-R&D-ratio.<sup>3</sup> The U.S. leads in dollar amounts, followed by the European Union (\$277 billion), China (\$183 billion), Japan (\$133 billion) and South Korea (\$55 billion).<sup>4</sup>

In 2012, business-funded R&D constituted the majority of the U.S. enterprise: the private sector provided 63% (\$317 billion) of the total funding. The federal government is the second largest funder of U.S. R&D, contributing 30% (\$136 billion) of the total. In terms of performance, the business sector employees represent 70% of the total while universities account for 14%. See Figure 1.

**Figure 1 Funding and Performing Sectors U.S. R & D Activities 2012**

Source: Boroush 2013



Of the nation’s R&D expenditures, 35% is spent on research and (\$75 billion [17%] on basic research, creating new knowledge; \$87 billion [19%], on applied research, identifying products) and 64% (\$291 billion) is spent on development, bringing products to market. As may be expected, the private sector dominates in applied research and development and universities in basic research. Increasingly, however, these demarcations are blurring as business is contributing more to basic research and universities are ramping up to operate in the applied research and development areas. For example, while the University of Pennsylvania and its peers have long histories in securing patents, they are increasingly engaged in providing business support and venture capital.

Privately supported research focuses HT manufacturing. Leading companies specialize in such fields as electronics, computer hardware and software and pharmaceuticals. In 2013, the leading companies were: Intel (\$10 billion), Microsoft (\$9.8 billion), Merck

<sup>2</sup> Mark Boroush, *National Patterns of R&D Resources: 2011–12 Data Update Detailed Statistical Tables* (NSF 14-304) December, 2013.

<sup>3</sup> Francisco Moris, John Jankowski, Mark Boroush, Marissa Crawford, and Jennifer Lee, “R&D Recognized as Investment in US GDP Statistics: GDP Increase Slightly Lowers GDP-to-R&D-Ratio.” *Info Brief* (NSF 15-315). March, 2015.

<sup>4</sup> World Bank, *World Development Indicators 2013* at <http://wdi.worldbank.org/table/5.13#>

(\$8.2 billion), Pfizer (\$7.9 billion), Johnson and Johnson (\$7.7 billion), GM (\$7.4 billion), Google (\$6.8 billion) and IBM (\$6.3 billion).<sup>5</sup> A recent study of 3,445 private sector sponsored R&D labs in the United States indicated their concentration in the Northeast corridor, around the Great Lakes, in California's Bay Area, and in southern California.<sup>6</sup> A recent report on private sector investment trends from 1980 to 2007, discloses that investment in basic research by large corporations has declined.<sup>7</sup>

### Figure 2 Location of Private R&D Labs

Source: Buzard, Carlino et al 2015



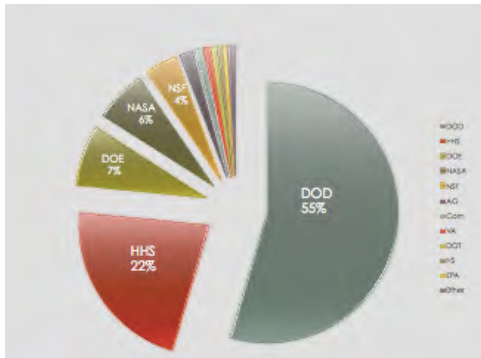
On the federal government side, the largest funders are the U.S. Departments of Defense (54% of the total U.S. R&D budgets), Health and Human Services with the National Institute of Health and National Institute of Mental Health (22%), and Energy (8%). The federal government allocates 46% of its total allocations to universities. It also devotes sizeable amounts to nationally-run laboratories and the private sector. For example, the Department of Health and Human Services' National Institute of Health supports 27 institutes and centers while the Department of Energy funds 17 national labs and five technology centers. See Figures 3 and 4.

<sup>5</sup> PwC "2013 Top 20 R&D Spenders" <http://www.strategyand.pwc.com/global/home/what-we-think/global-innovation-1000/top-innovators-spenders>

<sup>6</sup> Kristy Buzard and Gerald A. Carlino. *The Geography of Research and Development Activity in the United States*, Working Paper 09-16. Philadelphia: Federal Reserve Bank of Philadelphia, 2009; Kristy Buzard, Gerald A. Carlino, Robert M. Hunter, Jake K. Carr, Tony E. Smith. "Localized Knowledge Spillovers: Evidence of the Agglomeration of American R&D Labs and Patent Data. Working Paper 15-03. Philadelphia: Federal Reserve Bank of Philadelphia, January 2015.

<sup>7</sup> Ashish Arora, Sharon Belenzon and Andrea Pattaconi, "Killing the Golden Goose? The Decline of Science in Corporate Research, Working Paper 20902, National Bureau of Economic Research, January 2015.

**Figure 3 U.S. Federal R&D Funding (by Agency)**  
Source: Sargent 2013



**Figure 4 Department of Energy Labs**  
Source: US Department of Energy



In 2012, U.S. universities had R&D expenditures of \$63 billion with 59% of the total coming from federal sources; 22% from university sources and the remainder from non-federal or other non-profit organizations. These universities spent \$40 billion on basic research, 60% (\$24 billion) of which was from the federal government. Universities perform more than half (54%) of the nation’s federally funded basic research.

Of the 896 schools that received federal money for R&D, about 125 (14%) are extremely active, generating most of the basic research. Ten universities are dominant, receiving approximately 20% of the federal funding.<sup>8</sup> Notably, 60% of these top ten schools are located in urban areas, a factor that is important to both the institutions and the cities in which they are located as will be discussed later in this paper

**Figure 5 Top Ten University Recipients of Federal Funds 2011** (Northeast Corridor universities in red) Source: Lombardi et al 2012

University	Total R&D	R&D from federal government	Agency (primary funders)
Johns Hopkins	\$1.88 billion	88%	DOD, NASA
University of Washington, Seattle	\$ 949 million	83%	HHS, NSF
University of Michigan	\$ 820 million	64%	NA
University of Pennsylvania	\$ 814 million	79.8%	HHS
University of Pittsburgh	\$ 662 million	73.7%	HHS
Stanford University	\$ 656 million	72.3%	DOD, HHS, NASA, NSF, DOE
Columbia University	\$ 645 million	73.4%	NSF, NASA
University of California, San Diego	\$ 637 million	63.1%	
University of Wisconsin - Madison	\$ 594 million	53.4%	HHS, NSF
Duke University	\$ 585 million	57.3	HHS

The spatial expression of R&D and the spin off enterprises it creates have taken many forms. Captured conceptually, Figure 6 illustrates a typical auto-dependent U.S. metropolitan area encompassing a city and its surrounding suburbs.

<sup>8</sup> John Lombardi, Elizabeth Phillips, Craig Abbey and Diane Craig, *The Top Ten American Research Universities*, Phoenix, AZ and Amherst, MA: The Center for Measuring University Performance, 2012.

**Figure 6 Typology of Tech Enterprise Including R&D Operations**

Source: Forsyth 2014

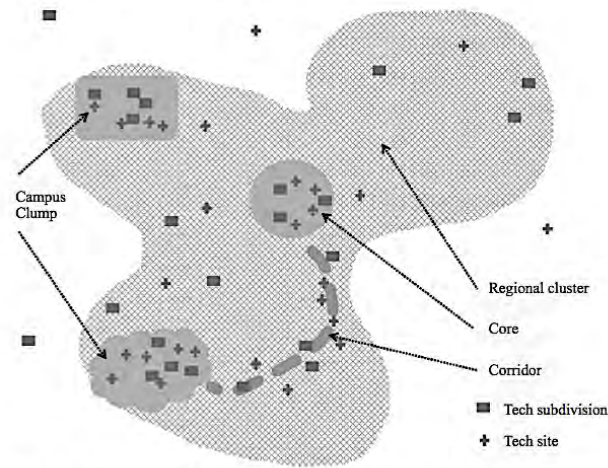


Figure 6 identifies the four spatial types of R&D enterprises: on campuses (representing here traditional university campuses and technology parks), along corridors (primarily private sector R&D operations close to universities), in core downtown areas (as cities often make land available to universities as part of revitalization schemes) and on scattered sites (typically individual companies or groups of researchers).<sup>9</sup>

## PART 2. HISTORY OF UNIVERSITY-BASED RESEARCH IN THE UNITED STATES

Over the past century and a half, U.S. research universities have emerged as a significant national asset for stimulating innovation through research especially in the basic sciences, technology and health. This evolution was the result of deliberate federal and state policies. The 1862 Morrill Act (and subsequent amendments) offered federal land to states (30,000 acres per member of a state's congressional delegation) that created institutions dedicated to instruction and research in agriculture and engineering; it thus established a partnership between the federal government and the states in building universities to support a modern agricultural sciences and industrial economy for the twentieth century. The list of the top ten research universities in Figure 5 demonstrates their strength of this effort, as four of the ten are land grant or public institutions.

Today's university-based R&D infrastructure is relatively new, dating from the 1950s when following World War Two, the federal government revisited its research policies. The importance of government-sponsored university research had intensified during the War leading to breakthrough discoveries critical to the Allied victory, including radar, the proximity fuse, penicillin, DDT, the computer, jet propulsion, and the atomic bomb.<sup>10</sup> Drawing on this experience, the government opted for decentralizing publicly funded

<sup>9</sup> Ann Forsyth, "Alternative Forms of the High-Technology District: Corridors, Clumps, Cores, Campuses, Subdivisions, and Sites" *Environment and Planning C: Government and Policy* 2014, 32.,

<sup>10</sup> Ali Madanipour, *Knowledge Economy and the City: Spaces of Knowledge* (New York: Routledge, 2011), 153, O'Mara, Margaret Pugh. *Cities of Knowledge: Cold War Science and the Search for the Next Silicon Valley* Princeton, NJ: Princeton University Press, 2005.

research in defense and health activities to universities. It created key funding authorities: the National Institute of Health (1947) and the National Science Foundation (1950) while increasing R&D budgets to other federal agencies, including the Department of Defense. Between 1953 and 2012, federal allocations for R&D increased 588% (in constant 2005 dollars: from \$17 billion to \$117 billion).<sup>11</sup>

Federal support has included both operating costs and capital costs. Thus, universities have gained money to hire faculty researchers *and* to build the labs in which they would work. The federal government and universities have negotiated formulae for these allocations with the capital proportion or overhead amounting to 50 or 60% of operating budget. A university might be awarded grant of \$1.6 million – \$600,000 of which would be overhead. In terms of knowledge creation, the results have been dramatic: “The laser, magnetic-resonance imaging, FM radio, the algorithm for Google searches, global-positioning systems, DNA fingerprinting, fetal monitoring, bar codes, transistors, improved weather forecasting, mainframe computers, scientific cattle breeding, advanced methods of surveying public opinion, even Viagra had their origins in America’s research universities.”<sup>12</sup> The results have been equally dramatic in terms of the expansion of capital facilities, with universities adding millions of square feet of laboratories and associated offices.

The university-led research originally took place within the confines of the institutions’ campuses – and while this practice is changing, much does still occur there. The history of campus expansion is fraught with controversy since many institutions are located in heavily populated residential areas where securing land is economically and politically expensive. Lab space competes for dormitory and instructional space in many instances. For those labs associated with clinical research and campus hospitals, on campus locations are critical. But for other types of research, being immediately proximate is not critical which has led universities to secure (either independently or with partners) nearby but less expensive property to form research or technology (tech) parks.

Universities view these developments as having multiple purposes. Not restricted solely to university operations, they attract private-sector and other non-profit research groups. This mixture helps defray development and operating costs while creating agglomeration advantages. Often universities will directly offer tenant companies enhanced infrastructure, supporting facilities, or access to university laboratory spaces.<sup>13</sup> They may offer additional business services such as shared legal and accounting aid. In addition, firms locating in university tech parks accrue other less tangible benefits, including the potential for greater interaction with researchers and students of the associated university, increased idea transfer from one firm to another, as well as the overall positive externalities due to clustering. Tech parks have become a common complement to the modern research university, reflecting current pressures on universities to shift from their traditional role of education to be more entrepreneurial, engaging in economic development of their regions.<sup>14</sup>

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<sup>11</sup> Boroush, *National Patterns*.

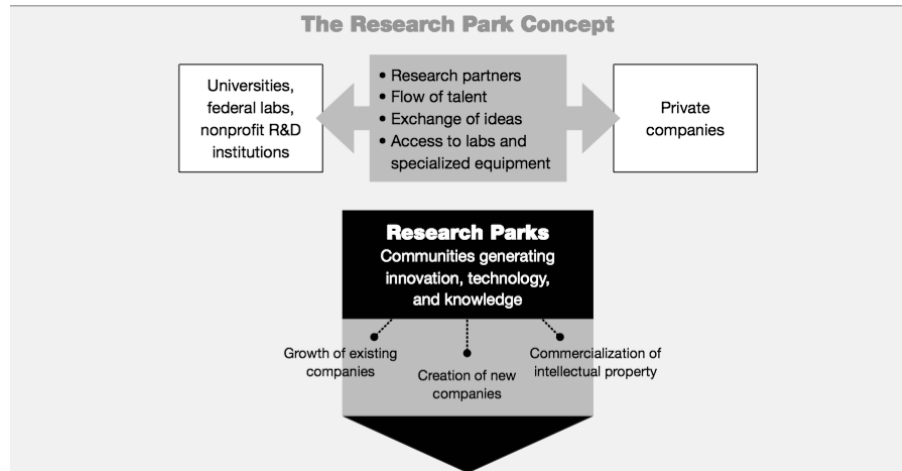
<sup>12</sup> Jonathan Cole, *The Great American University* (New York: Public Affairs Press, 2010), 3.

<sup>13</sup> Willem van Winden et al., *Creating Knowledge Locations in Cities: Innovation and Integration Challenges* (New York: Routledge, 2012), 8.

<sup>14</sup> Ali Madanipour, *Knowledge Economy and the City: Spaces of Knowledge* (New York: Routledge, 2011), 153.

**Figure 7 Components of the Modern Research Park**

Source: Battelle 2007



In 2007, the United States and Canada had a combined 57 university tech parks, which encompassed more than 27,000 acres, about 1,000 buildings and 70 million square feet of leasable space.<sup>15</sup> By 2012, this number rose to 85. The typical university tech park is in a suburban community smaller than 500,000 people, is less than 120 acres in size, has primarily private-sector tenants, has a 95% or higher occupied rates and employs about 750 people, primarily in the information technology, pharmaceutical, and science and engineering sectors.<sup>16</sup> (See Appendix A.)

Early on, universities viewed tech parks as real estate development opportunities rather than as providing university/private-sector research partnerships.<sup>17</sup> This attitude changed with passage of the Patent and Trademark Law Amendments Act, more commonly known as the Bayh-Dole Act in 1980 which gave universities the lead role in transferring technology into the private sector through federally funded research. Rather than the government retaining patents to research outcomes conducted with federal funds, the institutions carrying out the research could now pursue commercialization of any inventions discovered as a result.

Universities began to develop proactive licensing offices that are adept at marketing the rights to use university-owned patents or knowledge for private business ventures. By investing in robust technology transfer operations, universities were able to leverage university assets and knowledge and to create more start-up activities that can then expand the uses of their tech parks. This technology transfer process has become the mainstream method of innovation in the biomedical field and is quickly becoming a

<sup>15</sup> Battelle Memorial Institute, *Characteristics and Trends in North American Research Parks* (Columbus, OH: Battelle, 2007), 4. Darmody, Brian. *The Power of Place 2.0: The Power of Innovation*. Tuscon, AZ: Association of University Research Parks, 2010. <http://aurp.memberclicks.net/assets/documents/AURPPowerofPlace2.pdf>

<sup>16</sup> Battelle, *Characteristics*. 5.

<sup>17</sup> Battelle. *Characteristics*, viii.



common technique for new business development in other technology fields as well. Massachusetts Institute of Technology has been especially skillful at this, spurring hundreds of companies and developing a guide for venture capitalist to navigate the investment process on the university's terms.<sup>18</sup>

Over this same time period, the design of university tech parks has evolved away from the original suburban location park-like layouts to urban locations with mixed-use and walkable designs.<sup>19</sup> Rather than being isolated, separate sites, the newest tech parks – now labeled innovation districts – are being integrated into urban areas. These high-value sites mix university activities, research spaces, housing, and additional amenities like restaurants or retail outlets to create fully functioning research neighborhoods.<sup>20</sup> Many university officials believe that these live-work neighborhoods create more opportunities for interaction and collaboration and are attractive to high-value knowledge workers and to a new generation of students who are drawn to an urban lifestyle. This style of development also supports today's methods of technology advancement that use collaborative teams from a variety of different backgrounds.<sup>21</sup> See Figure 8.

### Figure 8 University-Led Technology Parks: Yesterday and Today

Source: Research Triangle Park Foundation, 2011; Drexel University, 2014



A recent report by the Brookings Institution outlined the necessary ingredients for the success of these innovation districts. See Figure 9. In combining economic, physical and networking assets in urban, not suburban locations, they “focus extensively on creating a dynamic physical realm that strengthens proximity and knowledge spillovers. Rather than focus on discrete industries, innovation districts represent an intentional effort to create new products, technologies and market solutions through the convergence of disparate sectors and specializations (e.g., information technology and bioscience,

<sup>18</sup> Hannah Seligson, “Hatching Ideas, and Companies, by the Dozen at M.I.T.,” *The New York Times*, November 24, 2012, BU1.

<sup>19</sup> Battelle, *Characteristics*, 24.

<sup>20</sup> Richard Florida, *Cities and the Creative Class* (New York: Routledge, 2005), 144; Bruce Katz and Julie Wagner, *The Rise of Innovation Districts: A New Geography of Innovation in America* (Washington, DC: Metropolitan Policy Program at Brookings, May, 2014), Wong, Wailin. “South Bend aims to keep Notre Dame innovations in town with new technology park.” *Chicago Tribune*, September 6, 2011. Web.

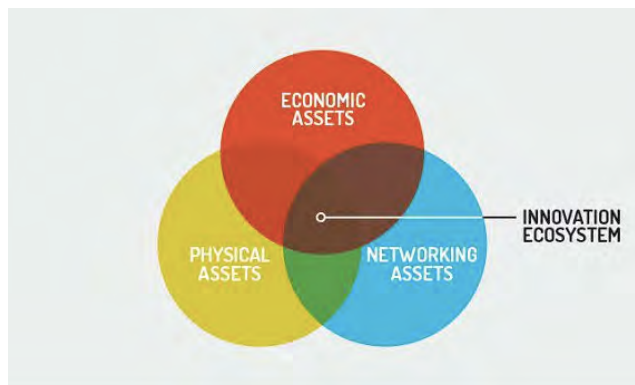
[http://articles.chicagotribune.com/2011-09-06/business/ct-biz-0906-bf-tech-park-20110906\\_1\\_ignition-park-innovation-park-economic-development](http://articles.chicagotribune.com/2011-09-06/business/ct-biz-0906-bf-tech-park-20110906_1_ignition-park-innovation-park-economic-development)

<sup>21</sup> Willem van Winden et al., *Creating Knowledge Locations in Cities: Innovation and Integration Challenges* (New York: Routledge, 2012), 15.

energy, or education).”<sup>22</sup> The report goes on to identify exemplary places where these districts exist including Atlanta, Baltimore, Cambridge (MA), Philadelphia, Pittsburgh, San Diego, San Francisco and many others. It notes their common forms: 1. the anchor plus model centered on a university (within the campus); 2. the re-imagined urban areas (e.g. a disused waterfront industrial area); and 3. the urbanized science park (a redesign of the auto-dependent, single use, suburban tech park). What they share is the ability to engage and combine research and entrepreneurship. A follow-up analysis by the Brookings authors, revealed that “innovation districts capture a remarkable spatial pattern underway – the heightened clustering of anchor institutions, companies and start-ups in small geographic areas of central cities across the United States....”<sup>23</sup>

**Figure 9 Ingredients of Innovation Districts**

Source: Katz 2014



### **PART 3. THE NORTHEAST CORRIDOR CONTEXT AND THE PHILADELPHIA CASE STUDY**

The Northeast Corridor (NEC), the economic and political backbone of the United States, encompasses twelve states and 142 counties. Its population of 52.3 million (projected to increase to 70 million by 2050) supports a \$2.92 trillion economy, represents 17 % of the U.S. population, and generates 20 % of the nation’s GDP. Relatively dense land use characterizes the region, which encompasses 2% of the nation’s land area.<sup>24</sup> Its major cities and metropolitan areas, including Boston, New York, Philadelphia, Baltimore, and Washington D.C. and its smaller places – such as Bethlehem, Providence, Hartford, New Haven, White Plains, Newark, Trenton, and Wilmington – host numerous anchor institutions.

#### **Philadelphia**

The Greater Philadelphia Region (GPR) sits in the center of the NEC, contributes 14 % of the NEC population and 13% of the NEC economic output. Although the GPR contains six metropolitan statistical areas (MSAs), the Philadelphia MSA is dominant. As the nation’s

<sup>22</sup> Katz and Wagner, *The Rise of Innovation Districts*, 2.

<sup>23</sup> Bruce Katz, Jennifer S. Vey and Julie Wagner, “One Year After: Observations on the Rise of Innovation Districts,” (Washington DC: Metropolitan Policy Program at Brookings, June 24, 2015), 1.

<sup>24</sup> E.L Birch, “Anchor Institutions in the Northeast Megaregion: An Important but Not Fully Realized Resource,” in Susan M. Wachter and Kimberly Zeuli (editors), *Revitalizing America’s Cities* (Philadelphia: University of Pennsylvania Press, 2013).

sixth most populous MSA (6 million population), it contributes more than 90% of the region's total GDP. Notably, for every \$1,000 of the region's GDP, \$3.86 is spent on university-based research, 6% from business-sponsored activities (slightly above the 5% national average) and the remainder from other sources, mainly the federal government.<sup>25</sup> Among the nation's ten fastest growing metro GDPs,<sup>26</sup> in addition to increases in education and knowledge services, its recent economic growth stems from distribution and electronic commerce, biopharmaceuticals and IT – all KTI activities. As recent experiences in other places – Boston, San Francisco, and even Pittsburgh – have demonstrated, research partnerships among universities and industry writ large have been keystones in economic success.

Philadelphia is the MSAs most important city, having a population of 1.5 million and contributing significantly to the metro GDP of \$383 billion. Once called the “Workshop of the World,” Philadelphia, like many NEC metros, lost its manufacturing sector in the mid 20<sup>th</sup> century. Factories for goods ranging from producing Baldwin locomotives to fabricating Stetson men's hats, were once the city's largest private employers. Peaking at more than 360,000 in the 1950s, the city now has 29,000 employees in the industrial sector. Within its 134 square miles (347 square kilometers) area, Philadelphia has more than 17,000 acres (7,200 hectares) of abandoned and unused industrial land. Arrayed in 16,000 individual parcels, these industrial zones constitute 21% of the city's land area.<sup>27</sup> In addition, the city controls another 1,200 acres (485 hectares) of lightly occupied land in its former naval yard, decommissioned and transferred to the city in 2000, administered by a separate authority, the Philadelphia Industrial Development Corporation (PIDC). Figure 10 portrays the industrial skyline at the turn of the 20<sup>th</sup> century and the dramatic slide in manufacturing jobs and the location of large plots of disused industrial land today.

In 2010, the city released an industrial lands study followed shortly by two plans, *The Lower Schuylkill Plan* for the 3,700-acre (1,500 hectares) area labeled Gray's Ferry in Figure 10, and the revised *Master Plan for the Naval Yard*.<sup>28</sup> The Lower Schuylkill area, which represents 28% of the city's industrially zoned land, is highly problematic, lightly occupied and heavily polluted. In contrast, the Naval Yard is on the rise. By January 2014 it had 11,000 employees working in 143 companies; a Marriott Hotel had opened as had the US headquarters of Glaxo Smith Kline, a 200,000 square-foot, double LEEDS Platinum building.

*The Lower Schuylkill Plan* calls for dividing the area into an Innovation District (512 acres/ 207 hectares), a Logistics Hub (1,132 acres/ 458 hectares) and an Energy Corridor (2,056 acres/32 hectares). It includes plans for adding 46 acres of green space for recreation and ecosystem services, upgraded river crossings and other improvements. Pennsylvania's growing shale oil and gas industries are targeting the Energy Corridor for

<sup>25</sup> Kenan Fikri, “Where the Innovation Partnership between Business and Academia is Thriving...and Where It is Not,” Advanced Industries Series (Washington, DC: The Brookings Institution, July 22, 2015).

<sup>26</sup> Delaware Valley Regional Planning Commission. *Investing in People and Places 2013*. Philadelphia: 2014.

<sup>27</sup> *An Industrial Land and Market Study for the City of Philadelphia 2010* (Prepared for the Philadelphia Industrial Development Corporation) Philadelphia: 2010.

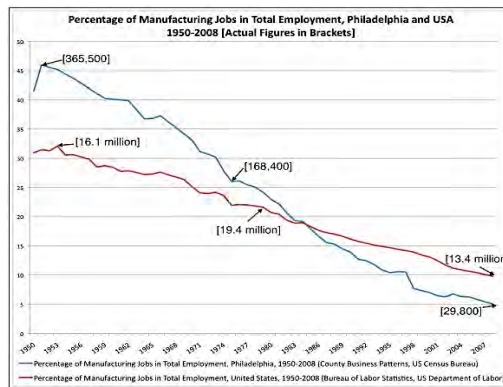
<sup>28</sup> Philadelphia Industrial Development Corporation, City of Philadelphia Department of Commerce, *The Lower Schuylkill Plan* (Philadelphia: 2012).

refining and distribution while university research needs are fueling some of the development in the Innovation District.

*The Lower Schuylkill Plan* links to the second plan, the *2013 Master Plan for the Philadelphia Naval Yard* which also places a premium on allocating land for R&D.<sup>29</sup> In this plan, PIDC notes that two areas within the Naval Yard are likely not developable in the immediate future: the 192 acres (78 hectares) that are under the control of the Philadelphia Regional Port Authority and are being held in reserve for port activities and the 450 acres (182 hectares) that comprise the “Shipyards,” the industrial heart of the site having four dry docks and rail connections. But for the remainder, PIDC has ambitious plans: a 38-acre (15 hectares) Canal District will actually get a canal and become an Class A office development due to the new amenity, the 81-acre (33 hectares) Mustin Park will be a class A office and light manufacturing area, the 72-acre (29 hectares) Central Green, already partially developed, will become a corporate center with a hotel (already built) and retail, and the 174-acre (70 hectares) Historic Core will include residences (a 1,000+ units) and facilities for research and education.

**Figure 10 Philadelphia’s Industrial Past and its Legacy**

Source: Philadelphia Industrial Development Corporation, 2012



Meanwhile, the region’s economy has adapted and is continuing to adapt to these changes.<sup>30</sup> Key industries are pharmaceutical, communications, food processing and the

<sup>29</sup> Philadelphia Industrial Development Corporation, *2013 Master Plan for the Philadelphia Naval Yard* (Philadelphia: 2013).

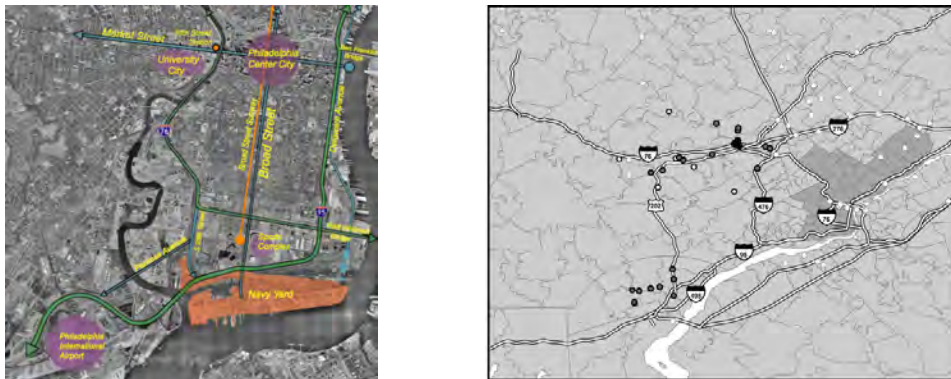
<sup>30</sup> Select Greater Philadelphia, *The Greater Philadelphia Regional Report 2013* (Philadelphia: 2013).

so-called “eds and meds.” The latter have become important economic drivers in the city, which is home to 75 universities, colleges and community colleges, including publically supported Temple University and private institutions such as Drexel University, Jefferson Medical School, University of the Arts, and the University of Pennsylvania (Penn).

In terms of R&D, Philadelphia sits in the center of the NEC’s pharmaceutical belt that extends from Delaware through New Jersey to the New York metro area and to Massachusetts’ Boston/Cambridge tech corridor. The presence of Philadelphia’s top-ranked medical schools and associated hospitals (e.g. Penn, Jefferson, Temple, Hahnemann), key pharmaceutical companies (e.g. Glaxo Smith Kline), and research universities fuels the enterprise. Comparing the city and its region to the conceptual spatial model (Figure 6) reveals broad conformity of the theorized spatial patterns of campus (University City and Navy Yard), core (Center City) and corridor (along the suburban interstate highways in King of Prussia, PA and Wilmington, DE). See Figure 11.

### Figure 11 Spatial Dimensions of University-Led Research in Philadelphia and its Environs

Source: Walsh *Plan Philly* 2009, Buzard and Carlino 2009



#### *University of Pennsylvania*

With more than 30,000 employees and a \$6 billion operating budget, Penn is the city’s largest single private employer.<sup>31</sup> Its 24,000 students, half undergraduate and half graduate students, occupy a 300-acre campus with 14 million square feet of development in 218 buildings. Founded by Benjamin Franklin in 1740 to train men for commerce and the professions, its practical bent has been its identifying quality for its entire history. Penn has 12 schools, all offering advanced degrees. It produces about 500 PhDs annually, the majority in the sciences and engineering.

Having a Carnegie Classification of “very high research activity,” Penn’s research generates nearly \$900 million of external funding annually, concentrated primarily in health and engineering. Its 4,300 faculty, 1,100 postdoctoral fellows and 5,400 support

<sup>31</sup> University of Pennsylvania, Penn Economic Impact Report 2010  
[http://www.evp.upenn.edu/pdf/PennEconomicImpact\\_SlideShow.pdf](http://www.evp.upenn.edu/pdf/PennEconomicImpact_SlideShow.pdf)

staff and graduate assistants comprise the backbone of its research capacity.<sup>32</sup> In the past ten years, nine faculty members have received the Nobel Prize. Penn researchers produced the world’s first computer, ENIAC, the Rubella and Hepatitis B vaccines, the basic science for in vitro fertilization, the dialysis machine and more recently important advances in graphene, T-cell therapy for leukemia and Transcriptome *In Vivo* Analysis.

Over time, the campus has grown to accommodate the demands for research labs. In addition Penn has partnered on or acquired three other sites: the University City Science Center (adjacent to the campus), the Philadelphia Naval Yard (5 miles away) and Pennovation Works (1.2 miles away). Since the 1950s Penn has had a vice provost for research and has developed supportive infrastructure including the Office of Research Administration to help with financial administration, the Center for Technology Transfer to help with patents and licensing, and UpStart, to provide business creation counseling. Tech transfer or translation of basic research to applied applications is becoming increasingly important for universities.<sup>33</sup>

By June 2014, Penn consolidated many of these functions in the Penn Center for Innovation, a multi-service office whose mission is “to translate Penn discoveries and ideas into new products and businesses for the benefit of society.”<sup>34</sup> With more than 30 employees, its mission is to facilitate university/industry partnerships especially in turning basic and applied research into products.

**Figure 12 University of Pennsylvania and Off-Campus Research Facilities**

Source: Eugenie L. Birch



On Campus Research Space

Since Penn moved to its present West Philadelphia location from the historic core in 1870, its footprint has grown. As can be seen in Figure 13, the campus expanded from a small lot to encompass a large surrounding area, a feat that has, in the past, created neighborhood tension. In the late 1950s and 60s the federal urban renewal program facilitated Penn’s massive building program by allowing for the acquisition of blighted

<sup>32</sup> Penn Facts <http://www.upenn.edu/about/facts.php>

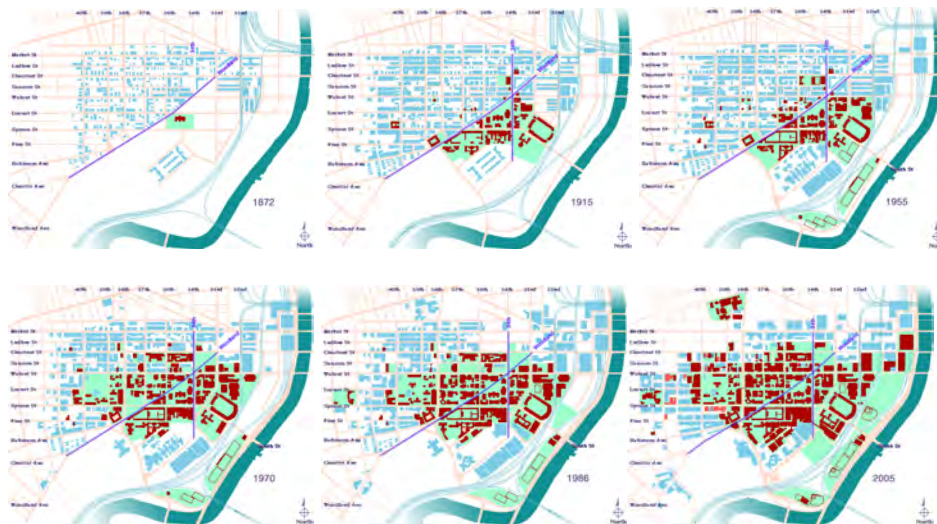
<sup>33</sup> Breznitz, Shiri, *The Fountain of Knowledge: The Role of Universities in Economic Development* (Palo Alto: Stanford University Press, 2014).

<sup>34</sup> Lauren Hertzler, University of Pennsylvania Launches New Center on Innovation,” *Business Journals* <http://www.bizjournals.com/philadelphia/news/2014/06/02/university-of-pennsylvania>

land and helping finance the subsequent re- building. Demand for lab space was generated by the very rapid the expansion of federal research funding of which Penn was a major beneficiary. In 1941 about 2% of Penn’s annual income came from the federal grants, by 1951 the amount was 6% and by 1961, it totaled 21%.<sup>35</sup> Today, the number is about 17%.<sup>36</sup>

### Figure 13 University of Pennsylvania Campus Growth: 1872-2005

Source: Sorrentino 2013



Today, Penn has more than a million square feet of on-campus research space, largely centered on the health sciences schools – medicine, nursing, veterinary and dental medicine—and the hospital. As the need for research space grows, rather than building “out,” Penn is building “up” with the completion of a half million square-foot state-of-the-art Smilow Center for Translational Research wedged between the half-million square foot Perelman Center for Advanced Medicine and the Roberts Proton Center, the largest such facility in the world.

By 2004, then-President Judith Rodin, author of the “West Philadelphia Initiatives,” an internationally recognized neighborhood revitalization plan that has helped shape the campus’s immediate surroundings into a “Brookings-style” innovation district, pledged that the Penn would no longer extend its holdings or seek expansion space westward into residential areas, but instead would either build on its current holdings or seek expansion space in other areas of the city. Subsequently, under the leadership of the current president, Amy Gutmann, Penn acquired two 20+ acre parcels to the east, one of which (Postal Lands) is being held for future space needs, the other (Pennovation Works), is currently being developed for R&D.

<sup>35</sup> MacKenzie S. Carlson, *A History of the University City Science Center* (Philadelphia: University of Pennsylvania Archives, 1999) <http://www.archives.upenn.edu/histy/features/upwphil/ucscpart1.html>

<sup>36</sup> University of Pennsylvania, *Form 990 Return of Organizations Exempt from Income Tax 2012*

**Figure 14 Campus Laboratory Space and Smilow Center for Translational Research**

Source: University of Pennsylvania, Brian Agness (map)



### University City Science Center

In addition to continual campus enlargements that accelerated in the 1960s, Penn partnered with four nearby educational institutions (Drexel, Philadelphia College of Pharmacy and Science, Presbyterian Hospital, and Temple University) to create the University City Science Center, one of the nation's first tech parks and its first *urban* tech park. Also facilitated through urban renewal, the Center's site extends four blocks along Market Street, encompassing the 17 acres. Now run by the University City Science Center Foundation with 31 partners, the Center has grown to include 15 buildings dedicated to laboratories and research offices. Between 1963 and the early 2000s, Science City tenants generated 449 patents and incubated 155 businesses (whose 80% survival and regional retention rate has contributed more than 15,000 high wage jobs to the regional economy). In 2012 the Center generated \$22 million in revenues, principally from rental income from its more than 110 tenants.<sup>37</sup>

Under new leadership since 2008, the Center is being re-invented in a number of ways. First, Drexel is refurbishing two buildings, dating from the 1960s, for creative enterprises— the URBN Center focusing on the media arts and design and the ExCITE Center (Expressive and Interactive Technologies) bringing together fashion design, digital media, performing arts, computer and information science, product design and other creative fields to work collaboratively on research and other projects. Second, the Center is constructing two new mixed-use buildings adding residential and retail activities to its roster. Third, the Center has crafted more aggressive branding and formulated programming to support better today's start ups including Quorum, a networking forum with frequent meetings, QED, a proof-of-concept program targeting technology transfer jointly funded by the State, the Philadelphia Department of Commerce and the William Penn Foundation; Port Business Incubator, a floor with

<sup>37</sup> University City Science Center, *Inventing the Future, University City Science Center 2013 Review* (Philadelphia, 2013).



shared offices, wet labs, common amenities and a STEAM program, training for youth in science, technology, engineering, art and math. This area is slowly turning into the type of innovation district described by Brookings.

**Figure 15 University City Science Center: Today and Yesterday**

Source: University City Science Center Foundation, University of Pennsylvania Archives



Philadelphia Naval Yard

In 2010, Penn became one of the key partners of a team led by Penn State that successfully competed for one of four innovation cluster grants awarded by the U.S. Department of Energy (DOE). With \$120 million dollars from the DOE and the State of Pennsylvania, the team – composed of several universities, lead industries including United Technologies, and public sector entities such as Benjamin Franklin Technology Partners, and the state’s economic development arm – created the Consortium for Building Energy Innovation (CBEI) to focus on deep retrofits and associated work. The centerpiece of the five-year project is the adaptive reuse of a 38,000 square-foot former Naval Recreation Building to a state-of-the-art Center for Building Energy Science, to be used for research by the team.

Pennovation Works

In 2010, Penn acquired DuPont’s former Marshall Labs, which occupied a 23-acre site formerly used for research and development of automotive coverings. Remediation of any contaminants has occurred but only to a level that, under the State of Pennsylvania’s clean-up regulations, allows offices and labs but not residential use. Several buildings are on the site, including warehouse facilities and an ample advanced research lab having less than modern but serviceable equipment. A recent consultant study advised that the buildings were useable as is but that likely only four would be worth saving in the long run. The site sits along the banks of the Schuylkill River and has a wide band of greenery that connects to the riverfront bike trail. Although physically close to Penn’s Hospital and associated health schools, pedestrian and vehicular access is quite poor.<sup>38</sup>

<sup>38</sup> WRT *South Bank* (Philadelphia 2014).

**Figure 16 Pennovation Works: Its Site and Master Plan**

Source: University of Pennsylvania



Penn is currently using the facilities for a number of activities that need a significant amount of space but that cannot pay high rents. These include:

- The Penn Vet Working Dog Center, a research lab studying and training dogs to support first responders in emergency situations;
- Penn Dental Research Greenhouse, a research facility to test plants as shelf-stable incubators for medicine as a cost effective distribution method;
- Penn School of Arts & Sciences Bio Garden, as a space for researching how insects affect plants;
- Penn Transit Services, the University's fleet management operation of the University, which includes a new sustainable propane fueling station for the city;
- • KMEL Robotics, a spinoff of Penn's GRASP lab in the School of Engineering and Applied Science which is developing customized flying Quadrotor robots;
- Novapeptic, a start-up drug company developing treatment for diabetes;
- Jin+Ja, the offices of a locally produced health beverage company;
- *Edible Philly*, the local offices of a national publishing company focused on culinary arts;
- The Philadelphia Free Library Operations Center.<sup>39</sup>

Finally, Penn anticipates that the Penn Center for Innovation will anchor Pennovation Works, the area many are now refer to by the nickname, "Pennovation Center," which captures the University's aspirations.<sup>40</sup> While still in the development stage, Pennovation Center will likely become an innovation district of the type described by the Brookings Institution.

#### **PART 4. BUILDING CAPACITY FOR RESEARCH AMONG UNIVERSITIES ALONG THE NORTHEAST CORRIDOR**

Across the Northeast Corridor, universities and their associated medical centers

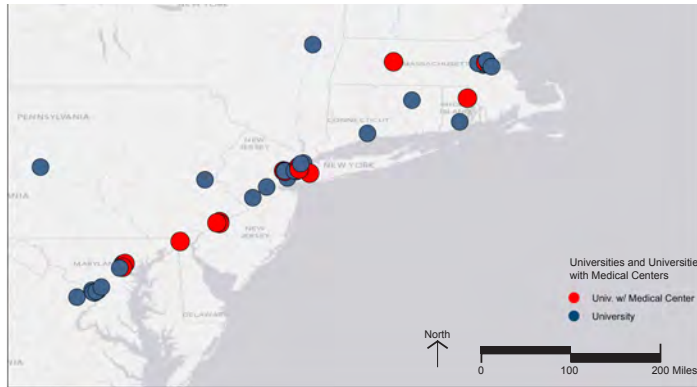
<sup>39</sup> <http://pci.upenn.edu/south-bank/>

<sup>40</sup> "UPenn Plans Massive 'Pennovation Center on the Schuylkill,'" *Philly Curbed* <http://philly.curbed.com/archives/2014/02/28/upenn-plans-massive-pennovation-center-on-the-schuylkill.php>

generate a substantial number of jobs, have multi-million and, in some cases, multi-billion-dollar operating and capital budgets, attract billions of dollars in government-sponsored research grants, private donations, and federal funds in the form of Medicare payments or student loans, and stimulate local spending through their own purchases as well as through expenditures by visitors and students. Figure 17 illustrates the number of universities and university-based hospitals in the NEC.

**Figure 17 Universities and University-based Hospitals in the Northeast Corridor**

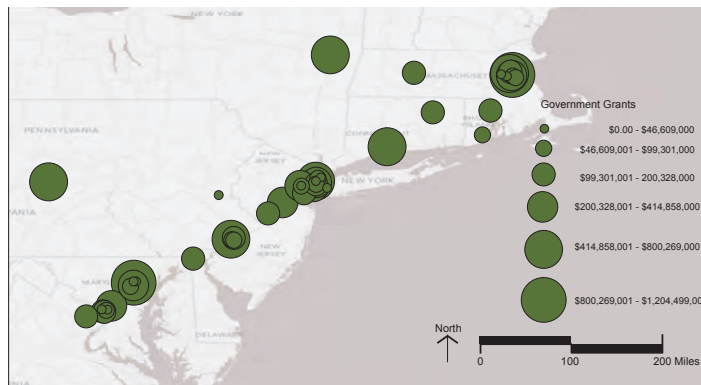
Source: Eugenie L. Birch



Data from national databases yield a rough estimate of these impacts. In 2010, major eds and meds anchors collectively employed nearly a million people, had aggregated operating budgets of nearly \$100 billion, attracted \$28 billion in sponsored programs, gifts, and contracts (\$23 billion from government grants and contracts, a minimum of \$5 billion in Medicare payments), and brought in upward of one-and-a-half million students.<sup>41</sup> As seen in Figure 18, the universities with high levels of research activity along the Northeast Corridor are arranged from north to south: Boston, Providence, New Haven, New York City and Baltimore.

**Figure 18 Universities and Federal Research Funding**

Source: Eugenie L. Birch



As Table 1 demonstrates, each NEC metro except Boston/Cambridge has one dominant

<sup>41</sup> Eugenie L. Birch, Anchor Institutions in the Northeast Corridor in Susan Wachter and Kim Zeuli, *Revitalizing American Cities* (Philadelphia: University of Pennsylvania Press) 2013..

institution. It also reveals that the dollar amount and mix of funding sources varies considerably among the institutions. At the highest levels, seven institutions have research funding that ranges from \$750+ million (Yale) to more than \$2 billion (Johns Hopkins). Johns Hopkins, Columbia and Penn are highly reliant on the federal government for their research funding – receiving 88%, 77% and 72% respectively of their totals from that source. At the other end of the scale is MIT (55% federal) relies on other sources – business and non-profit organizations for contributions to its research activities. Yale (64% federal), Harvard (59% federal) and Cornell (53% federal) each have institutional support amounting to about a quarter of their research expenditures. Despite these differences, the institutions receive significant dollar amounts of federal funds, a portion of which they employ for developing labs and other research facilities.

**Table 1 Research Expenditures and their Sources in High Research Universities in the Northeast Corridor 2012**

Source: Fikri 2015

Metro/University	All R&D expenditures	Federal government	State and local government	Institution funds	Business	Nonprofit organizations	O
<b>Boston/Cambridge</b>	<b>\$2,969,518</b>	NA	NA	NA	\$199,997	NA	NA
Boston University	368,281	267,194	194	76,482	4,633	13,940	5,838
Harvard	1,012,766	594,392	2,960	263,816	38,268	97,971	15,359
MIT	900,524	490,809	224	84,685	122,050	86,408	116,348
Northeastern University	116,088	85,170	1,375	22,999	4,780	1,764	0
Tufts University	156,525	113,450	2,533	14,056	10,706	13,490	2,290
<b>Providence</b>	<b>\$504,707</b>	NA	NA	NA	NA	NA	NA
Brown University	361,010	126,559	1,299	197,459	3,182	25,440	7,071
<b>New Haven</b>	<b>\$793,218</b>	NA	NA	NA	\$32,357	NA	NA
Yale University	788,784	503,227	6,401	190,162	32,318	53,739	2,937
<b>New York City</b>	<b>\$3,875,997</b>	NA	NA	NA	\$162,674	NA	NA
Columbia University	889,188	635,987	17,482	101,419	42,990	70,715	20,595
Cornell University*	845,184	445,116	69,682	191,099	29,214	81,185	28,888
Icahn Mount Sinai	428,654	277,517	3,522	78,121	29,302	39,450	742
New York University	428,654	277,517	3,522	78,121	29,302	39,450	742
Rockefeller	298,474	80,384	1,216	197,277	5,264	12,491	1,842
<b>Philadelphia</b>	<b>\$1,479,402</b>	NA	NA	NA	\$85,383	NA	NA
Drexel University	111,432	76,187	4,453	18,981	3,097	8,714	0
Temple University	224,087	131,872	4,040	63,048	10,251	11,454	3,422
Thomas Jefferson University	89,273	56,247	4,912	9,371	8,286	7,384	3,073
University of Pennsylvania	828,422	636,589	16,614	62,474	54,051	57,720	974
<b>Baltimore</b>	<b>\$2,276,710</b>	NA	NA	NA	\$49,438	NA	NA
Johns Hopkins	2,168,568	1,898,927	6,727	88,307	47,131	122,375	5,101

Approximately \$600 million of Cornell’s research funding is generated by the Weil Cornell Medical School in New York City

A brief description of the spatial arrangements that these universities are developing to support their research activities reveals patterns similar to those of the University of Pennsylvania. Tracing the experiences of Harvard, Cornell/Technion, Columbia and Johns Hopkins, reveals how they are seeking new ways to build and integrate innovation districts into their facilities portfolios.

***Boston/Cambridge***

Located in the 1,400 square mile, 4.6 million-population Boston-Cambridge, Newton,

MA-NH Metropolitan area, Boston (655,000 population) and Cambridge (109,000 population) experienced population increases of 6% and 4% respectively in the past four years, due to the nation's post 2008 economic recovery. The health of the area's basic industries including its anchor institutions contributed to the resurgence. The metro GDP is \$370 billion. For each \$1,000 of GDG, \$8.01 is spent on research – 7% from the private sector and the remainder from other sources, primarily the federal government. The leader in the sector is Harvard University, with MIT capturing nearly an equal amount of funding. Together, they had \$1.9 billion in research expenditures in 2012.

#### *Harvard University*

Harvard University, with a \$1 billion research budget,<sup>42</sup> has three primary campuses: its main campus, contains the school's original seventeenth-century buildings, set within 209 acres in the city of Cambridge; a second campus, the Longwood Medical Area (LMA), occupies 21 acres three miles south of Harvard's main campus, south of the Massachusetts Turnpike and adjacent to Boston's "Emerald Necklace" (an extensive chain of parks and parkways); and the third campus, the Allston Campus, encompassing 358 acres is directly across the Charles River from the main campus. Fully built-out, the main campus has limited options for infill development and none for expansion as it is surrounded by established neighborhoods. The Schools of Medicine, Dental Medicine, and Public Health dominate the LMA campus. These schools are a central part of the Boston region's medical services and research cluster. In addition to Harvard's Schools, several Harvard-affiliated hospitals and medical research centers, as well as unaffiliated institutions, are located adjacent to the LMA. As with the Cambridge campus, the LMA is largely built-out and constrained by the established neighborhoods and conservancy areas surrounding it.

As a result, Harvard is developing what it calls the Allston campus, an area one-and-a-half times the size of the Cambridge campus. Due to its size, Allston offers ample opportunity for growth. It has been home to Harvard Stadium since 1903 and Harvard Business School since 1908. The last major expansion in the area occurred in the 1970s when Harvard enlarged its recreation and athletic facilities.

Today, the Allston campus includes approximately 3.5 million square feet of space including: the Harvard Business School (1 .8 million square feet); athletic facilities (0 .5 million square feet); other university-affiliated buildings (1.1 million square feet); and other non-institutional uses (0 .3 million square feet). In the early 2000s, Harvard began building an enormous science center but, by 2008, aborted the project due to heavy losses to its endowment in the recession and the appointment of a new president who decided to revisit the plan. It fenced off the six-acre foundation for the science center and redrafted the plan, envisioning a slower development of a mixed-use innovation district.

As a symbol of its intentions, It invested in reconditioning an unused three-story television station as I-lab, an incubator facility offering dedicated space to student and alumni ventures, many of which are focused on global problems, for a finite period of time. It then invested in other amenities (including a restaurant), a shopping center, and

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<sup>42</sup> Fikri, "Where the Innovation Partnership between Business and Academia is Thriving..." July 22, 2015.

affordable housing in the relatively barren area before continuing construction on the research facilities.

When completed, the Allston campus will have its science center and six other projects— three new academic and administrative buildings totaling 340,000 square feet (Harvard Business School), a 300,000-square-foot mixed-use project (Barry’s Corner, a mixed-use venue and basketball facility), and a 250,000-square-foot hotel and conference center.

**Figure 19 The Harvard Campus and Plans for the Allston Campus** (Old Campus in blue; Allston Campus in red)  
 Source: Ehlenz and Birch



**New York**

Twenty million people live in the 7,000 square-mile New York-Newark-Jersey City NY NJ PA Metropolitan area. As the center of the nation’s financial and international trade industries, the region’s GDP is \$1.5 trillion. Here, for each \$1,000 of GDG, only \$2.63 is spent on research – 4% from the private sector and the remainder from other sources, primarily the federal government. However, in absolute dollars, this region’s R&D expenditures of nearly \$4 billion is 30% higher than that of the Boston MSA, 70% higher than in the Baltimore MSA and 160% higher than in the Philadelphia MSA. Several medical schools and universities contribute to New York City’s research effort, including Cornell University (Weil Cornell Medical College), Icahn School of Medicine, Mount Sinai, New York University (medical school and other units) and Columbia University (Medical Center and other units). The MSA also supports other high research centers including New Jersey’s Rutgers University and Long Island’s SUNY-Stonybrook.

*Cornell/Technion*

“City Seeks Partner to Open a Graduate School in Engineering” heralded the *New York Times* on December 16, 2010 in describing Deputy Mayor Robert Steel’s maiden public speech in which he announced the launch of Mayor Michael Bloomberg’s Applied Science Initiative. This global competition to attract a top-level engineering school to the city was a controversial move as the city already had several world-class universities such as Columbia, NYU and others. Nonetheless, Steel said that—despite already having more university students than Boston had total population—the city wanted to attract another world-class institution with deep research and educational capacities in the

applied sciences. With the tech sector emerging as a leading force in the economy, city leadership felt it did not have enough tech-focused talent to compete with San Francisco's Silicon Valley or the Boston region's Technology Corridor.

Although one of the strongest, most robust economies in the world, New York City was well behind its competitors in the number of engineers per capita, in R&D expenditures per capita, and in start-ups in applied science fields. Tech companies simply were not coming to New York. As a city with a long history of reinventing itself—it had been a center of sugar refining and other export products in the nineteenth century and a leader in the garment industry in the twentieth century – it now depended too heavily on finance, an industry shedding jobs in the aftermath of the 2008 crash. In response, New York City leaders seized upon the Applied Sciences Initiative as an opportunity to stimulate growth in the applied science sector and to rebrand the city as a center for technology start-ups and entrepreneurship. The competition was high-stakes with the winner taking rich rewards—free land and substantial funding.

Eighteen teams representing twenty-seven institutions responded to the City's call for proposals, which included strict criteria specifying that the institutions had to focus on applied science fields that emphasized solutions to real-world problems using cutting-edge innovations while fostering links with industry clusters. In addition, the applicants' proposals could include residential uses, commercial incubator, conference facilities, and amenities (e.g. retail, dining, hotels) space along with research and instructional spaces.<sup>43</sup>

Cornell University and Technion, Israel Institute of Technology – the team that as “Cornell Tech” ultimately won the competition – presented a proposal for an applied sciences campus on the tip of the two-mile-long 147-acre Roosevelt Island across the East River from Manhattan. When fully built, the campus will support two million square feet of university and privately owned buildings, co-located to integrate academia and industry. It will have a conference center and two-and-a-half acres of publicly accessible open space. As planned it will be an innovation district. Phase I of the project (2014-2017) includes an academic and a privately owned corporate co-location facility, as well as a residential building and a potential executive education center and hotel, developed and owned by private developers. Phase II (2017- 2037) will likely include two additional academic buildings, two corporate co-location buildings and two residential buildings. When completed, the campus will support several hundred faculty and more than 2,000 graduate students—nearly doubling the number of full-time graduate engineering students enrolled in Master's and PhD programs in New York City.

Cornell Tech is being designed as a revolutionary model in graduate education with extensive, deep interaction between academia and industry. Much of Cornell Tech's research will be organized around interdisciplinary “hubs” relevant to tech in New York City. While the hubs may change over time, initial areas include: “Healthier Life,” focused on health IT and mobile health; “Connective Media,” focused on extracting and using information from media data sources; and “Built Environment,” aimed to increase

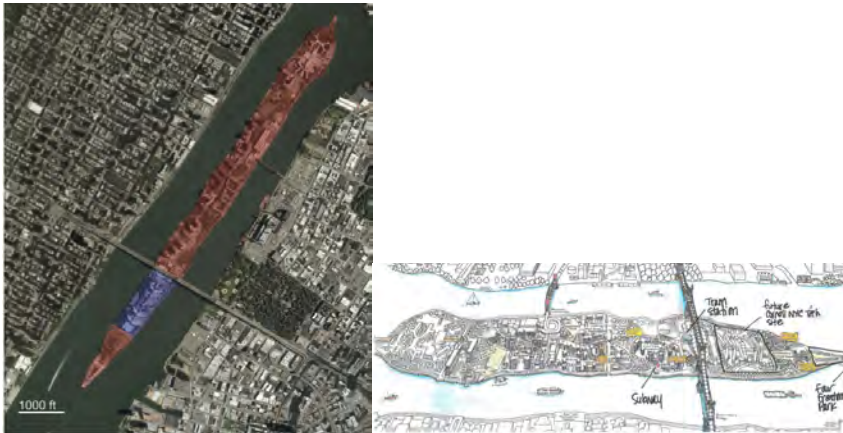
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<sup>43</sup> Fikri, “Where the Innovation Partnership between Business and Academia is Thriving...” July 22, 2015.

the efficiency and sustainability of urban environments. A core principle governing curriculum organization will be collaboration—among academic tracks, as well as with the city’s business communities. The academic programs, for example, require students to work with organizations and/or entrepreneurs to blend research and practical skills. Finally, the Cornell Tech campus plans include a resident entrepreneurial officer, as well as a venture capitalist in residence, a start-up incubator, and in-house product development space.

**Figure 20 Cornell Technion Proposed Campus on Roosevelt Island (in blue) and Plans for campus**

Source: Ehlenz and Birch



*Columbia University*

Like Penn and Harvard, Columbia University, one of the top ten recipients of federal funding (\$636 million in 2013 with the majority being at the Medical Center), has outgrown its two campuses, both in Upper Manhattan.<sup>44</sup> The 36-acre Morningside (main) campus at 116<sup>th</sup> Street and Broadway is fully built out while the 20-block Columbia University Medical Center that lies fifty blocks north in Washington Heights is also at capacity. To accommodate its research demands Columbia has in the past acquired individual sites opportunistically as they became available in either of its two neighborhoods, an approach that was both expensive and inefficient. Seeking an alternative, Columbia decided to build a new campus to service its existing facilities. In 2003, its leadership found a seventeen-acre site in Manhattanville—an underused, former industrial area of Harlem alongside the Hudson River, located one-half mile from Columbia’s Morningside Heights campus and a mile-and-a-half from its medical center. Although, Columbia University’s history of troubled relations with its neighbors, meant that any expansion would be complicated, the University negotiated with the community and city officials and by 2009 had developed a master plan with an associated \$150 million community benefits agreement that was acceptable to all parties.<sup>45</sup> When fully built over the decades ahead, the plan will add five to six million

<sup>44</sup> Fikri, “Where the Innovation Partnership between Business and Academia is Thriving... July 22, 2015.

<sup>46</sup> Aaron Fisher, Sasha Zients, and Garrett Donnelly, “Ties that Bind, Checking on the Manhattanville Community Benefits Agreement, Six Years Later,” *Columbia Spectator*, March 25, 2015.



square feet of university-programmed instructional and research space, at least 65,000 square feet of retail space, and approximately two acres of public space.

**Figure 21 Columbia University Morningside Campus** (existing and planned campus in blue, neighborhood in red); **illustration of first phase of Manhattanville campus build out** (color coded by phase).

Source: Ehlenz and Birch



Construction will occur over several decades as funds become available. Current developments include the construction of two major facilities, a central energy plant and a small plaza. The first facility, expected to open in 2016, is the nine-story Jerome L. Greene Science Center; it will include 450,000 square feet dedicated primarily to state-of-the-art academic research with 20,000 square feet of the ground floor used for retail and a community education center. The second facility, scheduled to open in 2017, is the five-story Lenfest Center for the Arts, with 50,000 square feet for an art gallery, a film screening room, performance space, and presentation space.

The first phase also includes the University Forum, a project with a 430-seat auditorium as well as space for up to 30 faculty members, a new School of International and Public Affairs building, and two new buildings for the Columbia Business School. Subsequent construction will encompass the development of eleven sites for research labs, instruction, and 825 units of faculty and graduate-student housing. Columbia's development plan includes nearly two million square feet dedicated to a central below-grade service area that will depress utility, freight and loading facilities, storage, and parking and enhance the pedestrian-friendly nature of the campus.

### **Baltimore**

Between 2010 and 2014, the Baltimore-Columbia-Towson MD metropolitan area 2.8 million population increased 3 – equaling the nation's growth rate. The region's GDP is \$168 billion. Here, for each \$1,000 of GDG, an astonishing \$13.48 (or \$2.3 billion) is spent on research – only 2% comes from the private sector and the remainder from other sources, primarily the federal government. Johns Hopkins University, with \$2.2 billion in research expenditures,<sup>46</sup> is not only the primary force in capturing research

<sup>46</sup> Fikri, "Where the Innovation Partnership between Business and Academia is Thriving..." July 22, 2015.

funding but also the region's largest employer.<sup>47</sup>

### *Johns Hopkins*

Johns Hopkins has three campuses and several associated satellite sites. Two campuses are in Baltimore. Two of the campuses are in Baltimore. The 140-acre Homewood campus, focused on undergraduate education and located in suburban-like north Baltimore is the main campus. Its 44-acre medical center is in East Baltimore, a heavily deteriorated, poverty-stricken neighborhood in the center city. The medical center and its affiliates have intense need for additional research facilities in East Baltimore.

### **Figure 22 Johns Hopkins East Baltimore Campus (blue) Surrounding Neighborhood and build out of residential community**

Source: Ehlenz and Birch



Working with the city and several foundations, Johns Hopkins leadership is executing the *East Baltimore Plan*, which covers 80 acres that when completed will include 2,100 units of mixed-income homeownership and rental housing units, 1.7 million square feet of life sciences research and office space, a new 7-acre community learning campus with an early childhood center, a public K-8 elementary school, fresh food stores and other uses. It is currently completing the first phase, 500+ units of mixed income housing, the school and park and 280,000 square feet of lab space.

### **CONCLUSION**

With annual expenditures reaching nearly half a trillion dollars, the United States leads the world in funding R&D. These expenditures, which have grown dramatically since the mid-20th century, have contributed to the nation's economic transition from one industrial mix to another and its growth in GDP. While the private sector provides the majority of R&D funds, national government agencies – notably the Departments of Defense, Health and Human Services and Energy – contribute nearly a third of the total, half of which goes to universities engaged in basic research. Although nearly a thousand institutions of higher education receive federal research grants, a smaller number are

<sup>47</sup> Johns Hopkins Economic Impact in Maryland, [http://web.jhu.edu/administration/gcpa/EIR\\_PDFs/15358%20Maryland1PgSumPrinterProof.pdf](http://web.jhu.edu/administration/gcpa/EIR_PDFs/15358%20Maryland1PgSumPrinterProof.pdf)

highly active and within this group, ten universities receive 20% of the total outlays. Six of the ten are in cities and three – Columbia, Penn, and Johns Hopkins – are in the Northeast Corridor. As structured, federal grants have had (and continue to have) a large impact on the spatial development of universities and their surroundings. They not only fund the researchers' salaries, including doctoral student support, but also pay for laboratories and other facilities in which the researchers work.

These latter kinds of expenditures have left physical imprints in the nation's cities and suburbs. These typically take four key forms: campus expansion (including technology parks), corridor/highway developments, downtown redevelopments and scattered-site projects. At one time, university-sponsored technology parks were important innovations. Developed to capture inexpensive, outlying or suburban land for university- and private-sector research, they tended to be single use and auto-dependent. Eighty-five are in existence today. Recently, more universities are fostering a new brand of development, the innovation district. Located in cities, featuring walkability and containing a mix of land uses including space for living, working, and recreation, the sponsors of these districts design them to attract highly valued knowledge workers and students. In fact, some landlords of suburban technology parks are "urbanizing" their holdings, adding housing, restaurants and other amenities.

With a focus on a Legacy City's efforts to plan to find ways to soften its rough transition from an industrially based economy to one that takes advantage of its own "eds and meds," and the region's key industries, especially pharmaceuticals and shale oil/gas, the Philadelphia case study outlines efforts to re-imagine and re-structure obsolete industrial areas. It focuses on a profile of the University of Pennsylvania and its multi-decade work to take advantage of the growth in federal research funding. Over time, Penn has developing a large number of research spaces, encompassing building on-campus labs and associated health facilities, sponsoring the nation's first in-town technology park, participating in multi-partner projects at the de-commissioned Naval Yard and the acquisition of a large, brownfield industrial site. Being one of the nation's largest recipients of federal research funds has justified this strategy. Whether current plans to provide inexpensive off-campus spaces at its newly acquired 23-acre Pennovation Works extension will be successful remains to be seen, but a notable feature of this era's conceptualization is linking the spatial enhancements with technical/administrative business counseling and commercialization efforts.

Finally, the brief survey of how four other highly active research universities are accommodating the demand for research space illustrates the strongly contextual solutions that these institutions, often in partnership with their localities, are producing, each with a slightly different twist. For example, Harvard and Johns Hopkins are concentrating on community-building AND research space expansion while Columbia and Cornell/Technion are experimenting with encouraging stronger ties between university-based research and their business communities.

All in all, R&D brings significant funding to institutions – private-sector entities and universities – in urban areas. While the traditional arrangements are in transition – as both types of institutions evolve their respective individual and collective roles in basic and applied research, the emerging efforts in the Northeast Corridor appear to be

redefining, regenerating and refueling the economies of former declining neighborhoods and industrial areas in Legacy Cities. While many unknowns remain, this paper notes the changes and advocates monitoring the phenomena in the years to come because as the Penn case illustrates, university-led urban revitalization is a slow process.

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#### *Additional Resources*

Association of University Research Parks (AURP)

6262 N. Swan Road, Suite 100  
Tucson, Arizona 85718 (USA)  
[www.arup.net](http://www.arup.net)

International Association of Science Parks (IASP)  
C/ Marie Curie, 35, (PTA)  
29590 – Campanillas – Málaga (SPAIN)  
[www.iasp.ws](http://www.iasp.ws)

The National Science Foundation (NSF)  
4201 Wilson Boulevard  
Arlington, Virginia 22230 (USA)  
[www.nsf.gov](http://www.nsf.gov)



**APPENDIX A***List of University Led Technology Parks in the United States and Canada*

	Tech Park	Associated Institution	Location
1	Arizona State University Research Park	Arizona State University	Tempe, AZ
2	Baylor Research and Innovation Collaborative	Baylor University/Texas State Technical College	Waco, TX
3	BioSquare at Boston University	Boston University	Boston, MA
4	Innovation Village	California State Polytechnic University, Pomona	Pomona, CA
5	Cal Poly Technology Park	California State Polytechnic University, San Luis Obispo	San Luis Obispo, CA
6	North Carolina Research Campus	Consortium of North Carolina Universities	Kannapolis, NC
7	Cornell NYC Tech	Cornell University	New York, NY
8	Florida Tech Research Park at Melbourne International	Florida Institute of Technology	Melbourne, FL
9	Research Park at Florida Atlantic University	Florida Atlantic University	Boca Raton, FL
10	Florida Gulf Coast University Innovation Hub	Florida Gulf Coast University	Fort Meyers, FL
11	Innovation Park	Florida State University	Tallahassee, FL
12	Georgia Tech Research Institute	Georgia Institute of Technology	Atlanta, GA
13	University Technology Park at IIT	Illinois Institute of Technology	Chicago, IL
14	Science & Technology Park at John Hopkins	John Hopkins University	Baltimore, MD
15	LSU Innovation Park	Louisiana State University	Baton Rouge, LA
16	University Park at MIT	Massachusetts Institute of Technology	Boston, MA
17	McMaster Innovation Park	McMaster University	Hamilton, ON, Canada
18	Montana State University Innovation Campus	Montana State University	Bozeman, MT

19	Gateway University Research Park	North Carolina Agricultural & Technical State University/University of North Carolina - Greensboro	Greensboro, NC
20	Centennial Campus	North Carolina State University	Raleigh, NC
21	NDSU Research & Technology Park	North Dakota State University	Fargo, ND
22	Illinois Science + Technology Park	Northwestern University	Skokie, IL
23	MetroTech Center	Polytechnic Institute of New York University	Brooklyn, NY
24	Purdue Research Park	Purdue University	West Lafayette, IN
25	Innovation Park at Queen's University	Queen's University	Kingston, ON, Canada
26	Rensselaer Technology Park	Rensselaer Polytechnic Institute (RPI)	Troy, NY
27	South Jersey Technology Park	Rowan University	Mullica Hill, NJ
28	South Dakota State University Innovation Campus	South Dakota State University	Brookings, SD
29	Stanford Research Park	Stanford University	Stanford, CA
30	Buffalo Niagara Medical Campus Innovation Center	SUNY, University at Buffalo	Buffalo, NY
31	Texas A&M University Research Park	Texas A&M University	College Station, TX
32	Science, Technology and Advanced Research (STAR) Park	Texas State University	San Marcos, TX
33	BioHio Research Park	The Ohio State University	Wooster, OH
34	Science & Technology Campus Corporation (SciTech)	The Ohio State University	Columbus, OH
35	Cummings Research Park	University of Alabama	Huntsville, AL
36	Edmonton Research Park	University of Alberta	Edmonton, AB, Canada
37	UA Tech Park	University of Arizona	Tuscon, AZ
38	Central Florida Research Park	University of Central Florida	Orlando, FL

39	Colorado Science + Technology Park at Fitzsimons	University of Colorado at Denver	Denver, CO
40	Delaware Technology Park Inc.	University of Delaware	Newark, DE
41	Science, Technology and Advanced Research Campus	University of Delaware	Newark, DE
42	Progress Corporate Park	University of Florida	Gainesville, FL
43	University of Guelph Research Park	University of Guelph	Guelph, ON, Canada
44	Energy Research Park	University of Houston	Houston, TX
45	Research Park	University of Illinois, Champaign-Urbana	Champaign, IL
46	Coldstream Research Campus	University of Kentucky	Lexington, KY
47	Nucleus: Kentucky Life Sciences and Innovation Center	University of Louisville	Louisville, KY
48	Smartpark	University of Manitoba	Winnipeg, MB, Canada
49	M Square Research Park	University of Maryland	College Park, MD
50	University of Maryland BioPark	University of Maryland - Baltimore	Baltimore, MD
51	Life Science & Technology Park	University of Miami	Miami, FL
52	Insight Park	University of Mississippi	Oxford, MS
53	Missouri Research Park	University of Missouri	Columbia, MO
54	Nebraska Technology Park	University of Nebraska	Lincoln, NE
55	Nebraska Innovation Campus	University of Nebraska	Lincoln, NE
56	University of New Orleans Research and Technology Park	University of New Orleans	New Orleans, LA
57	University Research Park	University of North Carolina - Charlotte	Charlotte, NC
58	The Research Triangle Park	University of North Carolina/Duke University/North Carolina State University	Durham, NC

59	UNT Discovery Park	University of North Texas	Denton, TX
60	Notre Dame Innovation Park	University of Notre Dame	South Bend, IN
61	University Research Campus	University of Oklahoma	Norman, OK
62	Riverfront Research Park	University of Oregon	Eugene, OR
63	University City Science Center	University of Pennsylvania	Philadelphia, PA
64	Transitional Research Lab	University of Pennsylvania	Philadelphia, PA
65	University of Pittsburg Applied Research Center (U-PARC)	University of Pittsburgh	Pittsburgh, PA
66	Innovation Place Research Park (Regina)	University of Regina	Regina, SK, Canada
67	Innovation Place Research Park (Saskatoon)	University of Saskatchewan in Saskatoon	Saskatoon, SK, Canada
68	InnoVista	University of South Carolina	Columbia, SC
69	USF Research Park	University of South Florida	Tampa, FL
70	MaRS Discovery District (Medical and Related Studies)	University of Toronto	Toronto, ON, Canada
71	Research Park	University of Utah	Salt Lake City, UT
72	Fontaine Research Park	University of Virginia	Charlottesville, VA
73	University of Virginia Research Park	University of Virginia	Charlottesville, VA
74	David Johnson Research & Technology Park	University of Waterloo	Waterloo, ON, Canada
75	University Research Park	University of Wisconsin - Madison	Madison, WI
76	Innovation Campus	University of Wisconsin - Milwaukee	Milwaukee, WI
77	Utah State University Innovation Campus	Utah State University	Logan, UT
78	Virginia BioTech Research Park	Virginia Commonwealth University	Richmond, VA
79	Virginia Tech Corporate Research Center	Virginia Polytechnic Institute	Blacksburg, VA

80	Wake Forest Innovation Quarter	Wake Forest University	Winston-Salem, NC
81	Piedmont Triad Research Park	Wake Forest University	Winston-Salem, NC
82	Tech Town Detroit	Wayne State University	Detroit, MI
83	West Virginia Regional Technology Park	West Virginia Higher Education Policy Commission (State University Consortium)	South Charleston, WV
84	Miami Valley Research Foundation	Wright State University/University of Dayton/Central State University/Sinclair Community College	Dayton, OH
85	Science Park at Yale	Yale University	New Haven, CT