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The Rise and Stall of the Lake Nona Biotech Cluster

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The Rise and Stall of the Lake Nona Biotech Cluster

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Abstract

The Rise and Stall of the Lake Nona Biotech Cluster

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Following the commitment of the new College of Medicine to locate at Lake Nona, the development of "Medical City" at Lake Nona officially began. The impact of the new cluster was expected to be quick and substantial. A decade later, policymakers and the public are largely disappointed by the lackluster impact of the Lake Nona cluster. This paper aims to understand how and why Medical City at Lake Nona has failed to meet expectations and whether there is hope for the industrial cluster to regain traction and achieve the success once envisioned.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

This chapter will provide background on Medical City at Lake Nona, discuss the objective of the paper, and detail the approach and methodologies used to arrive at conclusions.

BACKGROUND

In 1996 the Tavistock Group purchased 7,000 acres in Orlando, Florida and immediately began developing a master planned community called The Villages at Lake Nona. By 2003, however, Joe Lewis – the owner of Tavistock Group – was determined to use the land in a highly impactful and commercial manner. In light of a recent statewide efforts under Governor Jeb Bush to promote the biomedical industry, the Tavistock Group, along with local policymakers, decided to seed an industrial cluster at Lake Nona focused on the biotechnology and life science industries. In 2005, Tavistock donated 50 acres and $12.5 million to the recently approved UCF College of Medicine. Following the commitment of the new College of Medicine to locate at Lake Nona, a number of other prominent biotech firms agreed to locate in the community as well, effectively launching the development of "Medical City" at Lake Nona..

The impact of the new cluster was expected to be quick and substantial. By attracting large and established biotechnology companies such as the Sanford Burnham Institute, policymakers assumed they could fast forward the development of the industrial cluster. It was an idealistic and optimistic goal. It was expected that established research partners would continue to conduct innovative basic research, UCF and the College of Medicine would supply critical human capital, that functional partners (such as the Veterans Affairs research hospital) would provide an important conduit for translation

research, and that venture capitalists excited by the developments would fund spin-off companies dedicated to commercializing Lake Nona's research.

A 2006 study by the Milken Institute estimated that the industrial cluster (largely dependent upon the success of the College of Medicine) would create an additional $6.4 billion in economic impact by 2017 (roughly the 10th year of the operational phase of the new college).[1] Public expectations for the development were also substantial, and the development of Medical City was repeatedly compared to that of Walt Disney.

Ten years after the Milken Study and six years since Sanford Burnham and the College of Medicine opened their doors at Lake Nona, policymakers and the public are largely disappointed at the lackluster impact of the Lake Nona cluster. Many key partners have been delayed in opening their doors, employment commitments made by companies in return for state and local subsidies have not been achieved, no spinoffs have resulted from research efforts at the cluster, innovation through basic research has been minimal, and Florida has not succeeded in attracting greater degrees of venture capital.

OBJECTIVE

Although articles have been written criticizing the stalled development of Medical City, little research has been dedicated to exploring that reason for its lackluster performance. This paper aims to understand how and why Medical City at Lake Nona has failed to meet expectations and whether there is hope for the industrial cluster to regain traction and achieve the success once envisioned.

[1] Wong, Perry, and Armen Bedroussian. "Economic Benefits of Proposed University of Central Florida College of Medicine." *Santa Monica, CA: Milken Institute* (2006).

APPROACH

This paper begins by providing a background and history of the envisioned cluster at Lake Nona. Next, qualitative case studies of successful U.S. biotechnology clusters are conducted with the goal of applying lessons learned from their development towards the case at Lake Nona.

The reminder of the paper – Chapters 4 through 7 – considers elements which are considered key for the development of a successful biotechnology and life science cluster, including:

- **Funding.** Biotechnology is a high-cost industry and unique with respect to its dependence on both basic research funding (provided by NIH) and translational research funding (often provided by venture capitalists) to succeed. Chapters 4 and 5 analyze recent trends in NIH funding and venture capital to understand how these trends may have impacted development efforts at Lake Nona.
- **The strength of anchor institutions.** Anchor institutions are often responsible for promoting the development of an industrial cluster by providing expertise, networking opportunities, and bolstering the reputation of a cluster. Academic institutions often serve as important anchor institutions in high technology clusters. As reflected in the frequently cited 2006 Milken Institute report, the UCF College of Medicine was largely regarded as such an academic anchor for Lake Nona. The successes and challenges of the college are analyzed in Chapter 6. Given the weakness of the college to date, the strength of UCF more broadly is analyzed in Chapter 7 in order to understand how the university would have compensated for the weak College of Medicine to support Lake Nona's development.

Information was collected from reputable academic and news sources, as well as from one-on-one interviews with academics knowledgeable of local economic development issues in North Central Florida.

Chapter 2: The Rise and Stall of Lake Nona

This chapter attempts to introduce and give background to the Lake Nona cluster by: 1) defining the biotechnology industry and introducing the idea of a cluster; 2) explaining rationale and efforts to promote the biotechnology industry in Florida; 3) describing the establishment of Lake Nona and its initial successes, and; 4) discussing controversy surrounding its stalled performance.

BIOTECHNOLOGY IN THE U.S.

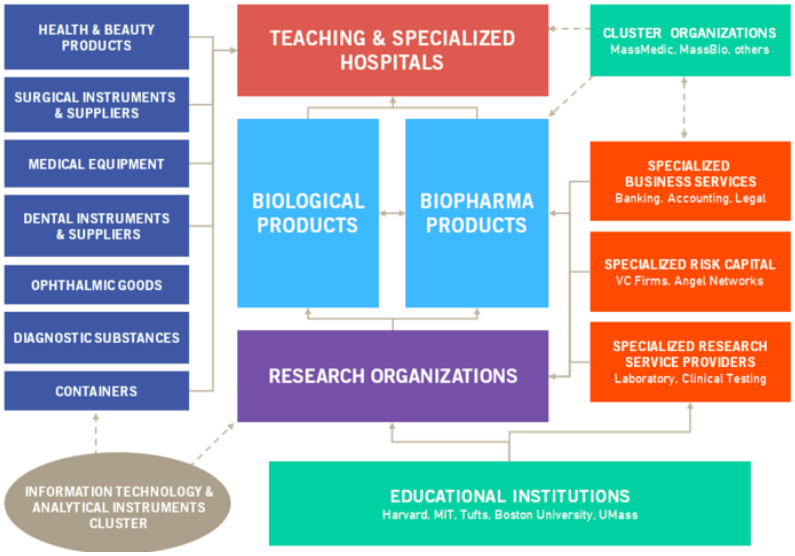
Biotechnology can be defined as the study and application of molecular and cellular processes to produce technologies which address human needs. Although the majority of the biotech industry is focused on human healthcare, many companies apply their research to develop products and services for agricultural productivity, food processing, industrial manufacturing, renewable resources, animal health, and environmental management. The biotechnology industry arose following the discovery of DNA in 1953 and experienced explosive growth following the discovery of recombinant DNA in 1973. According to IBIS World, the U.S. biotechnology industry consisted of 2,138 businesses, generated $109 billion in revenues and employed over 216,000 people in 2014.

Biotechnology firms tend to agglomerate in distinct geographic areas along with other businesses in the life science industries.[2] Such an agglomeration of interrelated industries is often referred to as a cluster. An industry cluster can be defined as a "group of similar and related firms in a defined geographic area that share common markets, technologies, worker skill needs, and which are often linked by buyer-seller

[2] The Milken Institute defines the "life sciences" as encompassing six major industries: pharmaceuticals, biotechnology, life sciences R&D, medical devices, health-care services, and supporting industries.

relationships."[3] Clusters consist of companies, suppliers, and service providers, as well as government agencies and other institutions that provide specialized training and education, information, research and technical support.[4] Figure 1 provides an illustrative anatomy of the biopharmaceuticals industry in Boston, Massachusetts as developed by the U.S. Cluster Mapping Project.

Figure 1: The Boston Biopharmaceuticals Cluster



Source: U.S. Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School.

[3] "Industry Clusters FAQ." Oregon Business Plan. Web. 1 Mar. 2016.
[4] "Clusters 101." *U.S. Cluster Mapping*. Harvard Business School. Web. 1 Mar. 2016.

Table 1 below identifies top U.S. biopharma clusters based on total industry employment. The location quotient, or share of local employment in an industry relative to the national average, is also provided.[5]

Table 1: Top 10 U.S. Biopharma Clusters in 2013 by Total Employment

Rank	MSA	Total Employment	Location Quotient
1	New York, NY	24,984	1.73
2	Chicago, IL	18,298	2.11
3	Los Angeles, CA	14,586	1.30
4	San Francisco, CA	13,801	3.43
5	Philadelphia, PA	10,930	2.08
6	Boston, MA	8,971	1.76
7	San Diego, CA	6,578	2.76
8	St. Louis, MO	4,250	1.49
9	Raleigh, NC	3,950	4.65
10	Grand Rapids, MI	3,760	3.95

Source: U.S. Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School.

POLICY DRIVEN BIOTECHNOLOGY IN FLORIDA

The success of high-profile industrial clusters like Silicon Valley has prompted many local leaders to seed entrepreneurial clusters within their regions. Policy makers justify such interventions by claiming that new firms promote positive economic growth and help to fight local poverty, and that imperfect credit markets would prevent these firms from ever locating to their region without government incentives.[6]

[5] The location quotient is an index for comparing employment in a particular industry relative to that of the national share. A location quotient greater than 1.0 has a higher concentration industry employment relative to the United States as a whole.

[6] Chatterji, Aaron, Edward L. Glaeser, and William R. Kerr. *Clusters of entrepreneurship and innovation*. No. w19013. National Bureau of Economic Research, 2013.

The promotion of the biotechnology industry has been a particularly competitive area of economic development at the state level, and under Governor Jeb Bush Florida developed one of the most aggressive plans to promote attract biotechnology businesses.[7] In 2003, Bush passed a $310 million incentive package to entice the California-based Scripps Research Institute to expand into Jupiter, Florida. Palm Beach County approved an additional $203 million in local subsidies to close the deal. This marked the beginning of a concerted policy effort by the Bush administration to promote and develop the biotech industry in Florida. In addition to high-paying jobs directly created by the recruited biotech research institutes, commercialization of their scientific discoveries was expected to result in a number of spin-off companies, attracting venture capital and other biotechnology companies to the state.

In 2006, in his last year as governor, Jeb Bush approved the creation of the Innovation Incentive Program (IIP) within the Department of Economic Opportunity (DEO) to "ensure that sufficient resources are available to allow the state to respond expeditiously to extraordinary economic opportunities and to compete effectively for high-value research and development, innovation business, and alternative and renewal energy projects."[8] Research and development entities, innovative businesses, and alternative and renewable energy companies are eligible to apply for program funds.

To qualify for the program, an applicant must agree to pay an average wage equaling at least 130% of the average private sector wage. All recipients must meet agreed-upon performance measures in order to receive funding, and – as of 2009 – reinvest up to

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[7] Weintraub, Arlene. "Jeb Bush's Big Biotech Push." *Bloomberg*. 11 Apr. 2006. Web. 1 Mar. 2016. http://www.bloomberg.com/news/articles/2006-04-11/jeb-bushs-big-biotech-push

[8] "The 2015 Florida Statutes." *Online Sunshine*. Florida Legislature. Web. 2 Mar. 2016. http://www.leg.state.fl.us/Statutes/index.cfm?App_mode=Display_Statute&Search_String=&URL=0200-0299/0288/Sections/0288.1089.html

15% of their royalties back into the state. Research and development (R&D) projects must furthermore:

- Serve as a catalyst for an emerging or evolving technology cluster;
- Demonstrate a plan for significant higher education collaboration;
- Provide the state a break-even economic benefit within 20 years; and
- Receive a one-to-one match from the local community.

With the exception of a 2013 agreement with an aircraft manufacturing firm, the program has primarily targeted biotech R&D businesses. According to data obtained from the DEO's Economic Development Portal, nine firms have been paid $359.1 million through the IIP to date (not including the $310 million paid to Scripps). A March 2015 article by Reuters estimated that state funding for IIP businesses and Scripps, combined with matching funds at the local level, have totaled over $1.32 billion. Table 2 contains a description of funds contracted to IIP recipients and to Scripps.

Table 2: State Funds Contracted and Awarded to Innovative Businesses

	Scripps Research Institute	Sanford Burnham Medical Research Institute	Torrey Pines Institute for Molecular Studies	SRI International	Hussman institute for Human Genomics	Max Planck Florida Corporation	Vaccine Gene Therapy Institute	Charles Stark Draper Laboratory, Inc.	IRX Therapeutics, Inc.
County	Palm Beach	Orange	St. Lucie	Pinellas	Miami-Dade	Palm Beach	St. Lucie	Hillsborough	Pinellas
IIP Recipient	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Date of Award	2003	10/30/2006	11/16/2006	11/22/2006	1/9/2008	3/12/2008	4/17/2008	6/30/2008	10/28/2011
Funding Agreement Term	N/A	20 years	20 years	20 years	12 years	20 years	20 years	20 years	20 years
Jobs Committed	N/A	303 by 2016	189 by 2015	200 by 2016	296 by 2016	135 by 2018	200 by 2018	165 by 2015	283 by 2017
Jobs Confirmed To Date	Not Available	234	124	86	139	94	120	61	Not Available
ROI Committed	N/A	$1.63	$3.53	$5.51	$2.54	$3.86	$4.66	$5.25	$13.77
Amount Contracted	$310,000,000	$155,272,000	$32,000,000	$20,000,000	$80,000,000	$94,090,000	$60,000,000	$15,000,000	$600,000
Amount Received	$310,000,000	$137,840,513	$27,772,000	$19,648,853	$59,200,000	$94,090,000	$60,000,000	$14,000,000	$600,000

Source: Department of Economic Opportunity's Economic Development Portal

SEEDING A CLUSTER AT LAKE NONA

Such a combination of public and private efforts provided the foundation for the development of Medical City at Lake Nona. A combination of state-level incentives under Governor Jeb Bush, local-level incentives provided by the Orlando community and the University of Central Florida, and private support from the Tavistock Group attracted a range of health and science firms to Lake Nona.

A study conducted by the Milken Institute in 2006 found that Orlando "possesses several of the attributes essential for the formation of a successful life-science industry" and that there was thus a "strong reason to believe that a life-science cluster could thrive in the Orlando region".[9] A strong hospital system, UCF's preexisting research strengths and technology commercialization efforts, community support, and adequate local physical infrastructure were among these essential attributes.

[9] Quintero, Fernando. "Burnham's Impact May Rival Disney's in Metro Orlando."*Orlando Sentinel*. Web. 3 Mar. 2016. <http://www.orlandosentinel.com/features/orl-burnham-overview-100409-story.html>.

The strength of the Orlando economy, combined with the array of financial incentives provided through the IIP, drew Sanford Burnham to Lake Nona. Sanford Burnham was among the first institutions to commit to locate to Medical City in 2006. As part of the Innovation Incentive Program, Sanford Burnham committed to delivering 303 high-paying jobs within ten years and a return on investment of $1.63 for every dollar invested by the state at the end of 20 years.

Expectations for Sanford Burnham's impact on the local economy, however, far exceeded the commitments made through the IIP as it was seen as an anchor institution for the Orlando life science cluster. Sanford Burnham's reputation, pivotal role in the development of the San Diego biotech cluster, and collaborative research approach were expected to draw in other biotech firms. Some reports anticipated the institute would yield local economic impacts on par with that of Disney.[10]

Indeed, a number of large partners located to Medical City soon after Sanford Burnham's commitment, including a new VA Hospital, Nemours Children's Hospital, M.D. Anderson (which has since relocated), the UCF College of Medicine, and a UF research facility. This constellation of life science firms attracted to Lake Nona would, in theory, form the foundation for the establishment of a biotech cluster in the Orlando region. Non-local experts saw potential in this policy-driven cluster development strategy; Duane Roth, CEO of CONNECT, a tech-business accelerator in San Diego, stated that "By convincing existing institutions like Burnham — which got its start here in San Diego — to expand to Orlando rather than trying to lure startups was nothing less than brilliant," Roth said. "That was a way to speed up the pace and not have to start from scratch."[11] Lake Nona partners themselves referenced cluster-like benefits as key reasons for locating at

[10] Ibid.
[11] Ibid.

Lake Nona; Sanford Burnham President and CEO John Reed stated that the chance to immediately be part of a cluster, "working in proximity to a diversity of partners," was the single biggest factor in his organization's decision to locate in Orlando.

LACKLUSTER PERFORMANCE OF LAKE NONA

Despite the promise and initial progress of the Lake Nona cluster, the cluster has not prospered as originally hoped. Several key partners have been slow to cement a presence in the area. The Burnett School of Biomedical Sciences, M.D. Anderson and Sanford Burnham were the first of the key Medical City partners to open in 2009, several years after their initial commitments.[1] Because of ties with another hospital in Florida - which located downtown instead of in Medical City - MD Anderson has actually left the Lake Nona medical complex. The College of Medicine – the presence and anticipated success of which was critical for several partners' decisions to locate at Lake Nona - did not open its building to until 2010 (see Chapter 6 for further details on the role and development of the UCF College of Medicine at Lake Nona). Nemours Children's Hospital and the UF Academic and Research Center did not open until late 2012, more than four years after their commitments. The huge VA hospital, which broke ground in 2008 and was initially expected to be completed in 2012, still is not fully operational (although some services opened in 2015).[12]

Underscoring the slow development of the cluster is the lackluster total employment within the medical plaza. According to the Florida Department of Economic Opportunity's Economic Development Incentive Portal, at the time this paper was written Sanford Burnham had only delivered 234 of the 303 professional positions promised by

[12] "Orlando VA Hospital Opens Years Behind Schedule." *Wesh.com*. Wesh Orlando, 26 May 2015. Web. 5 Mar. 2016. <http://www.wesh.com/health/dedication-planned-for-new-orlando-va-hospital/33202944>.

2016 as part of the Innovation Incentive Program (IIP). Other partners who established themselves much later at Lake Nona have also failed to deliver jobs as anticipated.

Furthermore, despite access to UF business incubators, not a single spinoff has been established based on research conducted by Lake Nona partners. This is important as spinoff companies are often considered a critical reflection of the success of an industrial cluster and the commercialization potential of basic research conducted by partners.

The struggles of Lake Nona, however, extend to other policy driven biotech efforts across the state. Critics have also noted the lackluster performance of other biotech firms which received large subsidies as part of Jeb Bush's IIP, including Torrey Pines and Scripps. Joe Cortright, an expert in city planning, noted that even "after the establishment of Scripps, Sanford-Burnham, and Torrey Pines, Florida has not received a higher percentage of venture capital money than it did 15 years ago."[13] In a 2014 report by Florida's Office of Economic and Demographic Research, the state of Florida itself acknowledged that the Innovation Incentive Fund "does not break even" when calculating economic returns.[14]

The lackluster development of the Lake Nona complex and key biotech firms supported under Jeb Bush's biotech push is particularly important to understand given the large sums of money dedicated to promoting their development. According to Reuters, when matching funds contributed by cities and counties to attracting biotech firms is taken into consideration, Florida spend more than $1.3 billion. The remainder of this paper is dedicated to analyzing the actual performance of Lake Nona, exploring the reasons for its

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[13] Bauder, Dan. "Florida Biotech Subsidies Not Working." *San Diego Reader*. San Diego Reader, 8 July 2015. Web. 4 Mar. 2016. <http://www.sandiegoreader.com/news/2015/jul/08/citylights1-florida-biotech-subsidies-not-working/#>.

[14] Szep, Jason. "How Jeb Bush's Big Bet on Florida Economy May Come Back to Haunt Him." *Reuters*. Reuters, 2 Mar. 2015. Web. 4 Mar. 2016. <http://www.reuters.com/article/us-usa-election-bush-biotech-insight-idUSKBN0LY0CH20150302>.

poor performance, and analyzing whether there is hope for the complex to meet expectations moving forward.

Chapter 3: Lessons Learned from Successful Biotech Clusters

After clarifying the concept of an industrial cluster, this chapter provides a qualitative analysis of the historical development of successful biotech and life sciences clusters in the United States - including Philadelphia, Boston and San Diego. Lessons learned from the development of these clusters is then applied to the situation at Lake Nona.

THE CONCEPT OF A CLUSTER

Biotechnology firms tend to form close to each other and other businesses in the life science industries, forming a cluster.[15] The concept of industrial clusters has its roots in the works of Alfred Marshall regarding the spatial concentration of firms,[16] and became a subject of intense research following Michael Porter's 1990 book titled The Competitive Advantage of Nations.[17] In later works, Porter called a cluster "a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities".[18] A later definition of clusters by Morisini as "a socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region" is also commonly referenced. In general, an industrial cluster can be understood as a group of similar and related firms in a defined geographic area that share common markets, technologies, and worker skill needs, often linked by buyer-seller relationships.

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[15] The Milken Institute defines the "life sciences" as encompassing six major industries: pharmaceuticals, biotechnology, life sciences R&D, medical devices, health-care services, and supporting industries.
[16] Marshall, Alfred, 1842-1924. Principles of Economics: an Introductory Volume. 8th ed. London: Macmillan and co., limited, 1936.
[17] Porter, Michael E., 1947-. The Competitive Advantage of Nations. New York: Free Press, 1990.
[18] Porter, Michael E. "Location, competition, and economic development: Local clusters in a global economy." *Economic development quarterly* 14.1 (2000): 15-34.

Clusters consist of companies, suppliers, and service providers, as well as government agencies and other institutions that provide specialized training and education, information, research and technical support.[19] The geographic concentration of firms in a related industry drives industrial productivity and innovation by promoting both competition and cooperation between firms. Easy access to specialized knowledge, labor, infrastructure, suppliers and customers reduces transaction costs for firms and enhances productivity. Clusters also promote innovation by allowing firms to gain insight into consumer preferences, providing them the opportunity to collaborate with others within their industry and simply heightening peer pressure.

Often an "anchor tenant" - usually a large established entity - fosters the development of a cluster. Universities frequently serve as anchor tenants for high tech industrial clusters like biotechnology and the life sciences more broadly. Strategic alliances with universities help firms access skilled labor, knowledge spillovers, complementary academic research and research facilities. The commercialization of publicly funded research also has substantial economic benefits for the local area. Hausman (2012) examines the extent to which universities stimulate nearby economic activity, finding that long-run employment and wages rise in industries related to a universities' preexisting innovative strengths, and that these benefits increase with geographic proximity to the university.[20] The power of local universities to engender economic growth has also been underscored by the work of Moretti (2004) who finds that university spillovers result in productivity gains for local industry, and Glaeser and Saiz (2004) who find that human capital is a strong predictor of both population and productivity growth in cities and

[19] "Clusters 101." *U.S. Cluster Mapping*. Harvard Business School. Web. 1 Mar. 2016.
[20] Hausman, Naomi. "University innovation, local economic growth, and entrepreneurship." *US Census Bureau Center for Economic Studies Paper No. CES-WP-12-10* (2012).

metropolitan areas.[21] Zucker et. al. (1998) highlight the critical role human capital as embodied in star scientists - often located at universities - in promoting the development of the biotechnology industry in particular.[22]

Not all areas with strong universities, however, have been able to develop high-tech clusters. The correlation between university research funding with patents and company start-ups is weak and not statistically significant.[23] In some biotech clusters, government labs, other large companies, and research institutions have driven the development of biotech industry, suggesting that universities are helpful but not by themselves adequate for successfully incubating a biotech cluster.

CASE STUDIES OF SUCCESSFUL BIOTECHNOLOGY CLUSTERS

A brief analysis of the development of mature U.S. biotechnology clusters was undertaken in order to gain insight into the key opportunities and barriers that drove the development of each one. Philadelphia, Boston, and San Diego were chosen for analysis because they rank among the top 10 biotechnology clusters in the country. San Diego was of particular interest given the expectations that Sanford Burnham will apply lessons learned from the San Diego cluster development to catalyze the development of Medical City at Lake Nona.

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[21] Glaeser, Edward L., and Albert Saiz. *The rise of the skilled city*. No. w10191. National Bureau of Economic Research, 2003.

[22] Zucker, Lynne G., Michael R. Darby, and Marilynn B. Brewer. *Intellectual capital and the birth of US biotechnology enterprises*. No. w4653. National Bureau of Economic Research, 1994.

[23] Feldman, Maryann. "The locational dynamics of the US biotech industry: knowledge externalities and the anchor hypothesis." *ATTI DEI CONVEGNI LINCEI-ACCADEMIA NAZIONALE DEI LINCEI* 203 (2004): 109.

Philadelphia

Philadelphia's current strengths in biotechnology go back to its prominent role in colonial history. As a cultural, industrial and commercial city Philadelphia was a natural center for innovation and began building academic and medical research infrastructure in the mid-18th century. In 1751, Benjamin Franklin and Dr. Thomas Bond founded America's first hospital, Pennsylvania Hospital, still a leading medical center. That same year, the University of Pennsylvania (also co-founded by Benjamin Franklin) held its first classes. By 1765 the University of Pennsylvania's School of Medicine was founded as America's first medical school.

Between 1790 and 1800 Philadelphia was the temporary capital of the United States, during which time both its population and position as an important industrial center in the new country were strengthened. The Embargo of 1807 and War of 1812 curtailed trade opportunities with Britain, further stimulating local innovation and industry; given that Britain was the major supplier of medicine at the time, medicine and pharmaceuticals were among these burgeoning industries.[24] Friends Hospital, America's first psychiatric hospital, was founded in 1813. In 1821, the American pharmaceutical industry was first organized by apothecaries with the creation of America's first college of pharmacy and pharmacists' association, the Philadelphia College of Pharmacy. Graduates of the Philadelphia College went on to found several of the largest pharmaceuticals in the world, including Eli Lilly and Company and GlaxoSmithKline, further cementing Philadelphia's position as a leader in the pharmaceutical industry. The American Pharmaceutical Association was founded in Philadelphia in 1852.

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[24] Feldman, Maryann, and Yda Schreuder. "Initial advantage: the origins of the geographic concentration of the pharmaceutical industry in the Mid-Atlantic region." *Industrial and Corporate Change* 5.3 (1996): 839-862.

Healthcare research and practice grew alongside pharmaceuticals in the first half of the 19th century. Jefferson Medical College was founded in 1824, the American Medical Association in 1847, and the Medical College of Pennsylvania in 1851.

The illnesses and injuries which accompanied the Civil War increased demand for Philadelphia's medical expertise. As one of the largest cities in the North and with existing strengths in medical research and pharmaceuticals, Philadelphia played a major role in receiving and treating the war's wounded. The 1860s saw the creation of a number of numerous medical and sciences establishments. The Wyeth, one of the largest pharmaceutical companies prior to its acquisition by Pfizer in 2009 – was founded in 1860. The momentum from the Civil War carried the development of the medical industry in Philadelphia through the last half of the 18th century, during which time Philadelphia Orthopedic Hospital, Johnson and Johnson, Merck Pharmaceuticals, and Wistar Institute (America's first independent biomedical research institute) were founded.

Philadelphia's medical expertise rested and built upon the foundations laid prior to the 20th century and provided a natural segue into its involvement in biotechnology. Centrocor, Philadelphia's first biotechnology company, was co-founded by the former director of the Wistar Institute. The founding of Cephalon in 1987 is considered the next key stepping stone in Philadelphia's development into a biomedical hub. Human capital, innovations and funding provided by strong pharmaceutical firms and universities encourage firms to locate in Philadelphia. However, Philadelphia remains relatively stronger in biomedical research than in commercialization.[25]

To summarize, the Philadelphia's strengths in medical research and pharmaceuticals are not due to any natural advantage (such as location near raw materials)

[25] Cortright, Joseph, and Heike Mayer. *Signs of life: The growth of biotechnology centers in the US*. Center on Urban and Metropolitan Policy, The Brookings Institution, 2002.

but historical circumstance.[26] A number of research, academic and professional organization founded during the colonial, revolutionary and industrial history of the city are still in existence today as leaders in their fields. This organizational and research strength enabled, in turn, enabled the growth of biotechnology industry in the area beginning in the late 1970s. The biotechnology industry, however, did not grow rapidly– eight full years existed between the establishment of the city's most frequently noted biotechnology firms. Although Philadelphia has maintained is reputation as a key player in the life sciences, it has struggled to translate its research strengths to commercialization on a scale that competes with other top life science and biotechnology clusters.[27]

Boston

Boston's current position as a leader in the life sciences is inextricably linked with the area's leading research and academic institutions. Harvard University, the nation's oldest institution of higher learning, was established in the Boston area in 1636, and its affiliated medical school was founded in 1782. The Massachusetts College of Pharmacy and Health Sciences, Massachusetts Institute of Technology (MIT), Tufts University and Boston College were but a handful of the universities founded in the Boston area during the 19th century. These universities were early leaders in the life sciences; MIT, as a technology oriented institute, initially considered life sciences from an engineering perspective, and collaboration between MIT and Harvard helped to found the Harvard School of Public Health in 1913.[28]

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[26] Feldman, Maryann, and Yda Schreuder. "Initial advantage: the origins of the geographic concentration of the pharmaceutical industry in the Mid-Atlantic region." *Industrial and Corporate Change* 5.3 (1996): 839-862.

[27] DeVol, Ross, et al. "The Greater Philadelphia Life Sciences Cluster." *The Milken Institute* (2005).

[28] Sharp, Phillip. "Life Sciences at MIT: A History and Perspective." *MIT Faculty Newsletter* XVIII.3 (2006). *MIT*. MIT. Web. 4 Mar. 2016. <http://web.mit.edu/fnl/volume/183/sharp.html>.

Leadership in the biomedical sphere is reflected in the receipt of numerous Nobel prizes even prior to the birth of biotechnology; Salvador Luria, David Baltimore and Baruj Benacerraf won Nobel Prizes in Physiology or Medicine in 1969, 1975 and 1980 respectively, and Walter Gilbert's work on the structure of DNA earned him the Nobel Prize in Chemistry in 1980. These star scientists attracted high levels of research funding; a 2009 study by the Milken Institute ranked Boston first among MSAs for life sciences R&D funding.[29]

Beyond providing human capital and research funding critical to life sciences and the niche biotechnology industry in particular, Boston area academic institutions were pioneers in the establishment of technology transfer.[30] MIT established an office for technology transfer as early as 1940, followed by Boston University and Medical Center in 1976, Harvard University in 1977 and Tufts University in 1978. This technology transfer infrastructure placed Boston universities in a unique position not only to support the biotechnology industry with basic research but assist in translation and commercialization. The value of pharmaceutical-biotech research contracts, an indicator of commercially promising biotech research activities, grew rapidly between 1980 and 2000, exceeding the value of these alliances in all other major biotechnology centers.[31]

Commercialization of life science and biotechnology discoveries was also supported by the strength of the venture capital system in Boston. Organized venture capital has its roots in efforts by New England leaders to strengthen the local and national economy by supporting small business; Boston figures were at the forefront of these

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[29] DeVol, Ross, et al. "The Greater Philadelphia Life Sciences Cluster." *The Milken Institute* (2005).
[30] Stevens, Ashley J. "The Biopharmaceutical Industry in Massachusetts-The Triple Helix in Action." *Journal of Biolaw and Business* 10.3 (2007): 33.
[31] Cortright, Joseph, and Heike Mayer. *Signs of life: The growth of biotechnology centers in the US*. Center on Urban and Metropolitan Policy, The Brookings Institution, 2002.

efforts.[32] The former dean of Harvard Business School and president of MIT joined forces in 1946 to establish the American Research and Development Corporation, one of the first two venture capital firms in the country.

Spinoffs from strong universities and medical centers, assisted by technology transfer programs and the access to venture capital, gave rise to a number of biotechnology companies beginning in the 1980s. Biogen, the first biotechnology company in Massachusetts, was founded in 1978 by researchers from Harvard and MIT. Genzyme, another early leader in the biotech industry, was established in 1981 based on research carried out at Tufts University. Commercialization activity gained momentum through the following decades; between 1980 and 2000 Boston had the largest concentration of biotechnology firms in the country, second only to San Francisco (the birthplace of biotechnology). Local government played an active role in encouraging the biotechnology cluster, establishing the Massachusetts Centers for Excellence Corporation (MCEC) and Massachusetts Biotechnology Council (MBC) to promote, organize and provide services to biotechnology companies.

Biotechnology as an industry is unique in its reliance on basic research and venture capital funding. Given that both of these elements were established in the Boston area prior to the 1980s, Boston was a natural place for the industry to establish itself beginning in the 1980's. Although a number of pharmaceutical firms, biotech companies and financial institutions arose to support the industry, organizational theorists Powell and Padgett (2012) have shown that the cluster was primarily dependent upon the networks

[32] Hsu, David H., and Martin Kenney. "Organizing venture capital: the rise and demise of American Research & Development Corporation, 1946–1973."*Industrial and Corporate Change* 14.4 (2005): 579-616.

promulgated by research institutes through the late 1990s, and would have collapsed without them.[33]

San Diego

Although the Scripps Institution of Oceanography (SIO) established an early life science research presence in San Diego, the formation of several non-profit research institutes in the mid-20th century formed the foundation for San Diego's eventual recognition as a life science industry cluster. The Scripps Research Institute (Scripps) was founded in 1955 with a focus on education and research in the biomedical sciences and today remains a leading life science research body in the nation. In 1960, Jonas Salk established the Salk Institute for Biological Studies in San Diego after the city donated land (which had previously been zoned by the city for research purposes) for its establishment. Several prominent bio-scientists including Francis Crick, known for his co-discovery of DNA, contributed to research efforts of the Salk Institute.

The area lacked a supporting academic research anchor until 1960, when the University of California at San Diego was established through state appropriations, a donation from the defense company General Dynamics and a gift of 63 acres from the city of San Diego in the Torrey Pines area close to SIO, Scripps and the Salk Institute.[34] In 1976 the Torrey Pines research zone gained another prominent tenant with the establishment of the La Jolla Cancer Research Center (now Sanford Burnham Prebys Medical Discovery Institute).

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[33] Padgett, John F., and Walter W. Powell. *The emergence of organizations and markets*. Princeton University Press, 2012.

[34] "Campus Timeline." UC San Diego. Web. 10 Mar. 2016. <http://ucsd.edu/timeline/>.

In addition to non-profit research institutes focused on the biomedical research, the military played an important role in building San Diego's research presence. A naval laboratory and federal R&D support built a research community focused on defense and attracted talented engineers and scientists. Research-oriented defense companies, including General Atomics (which supported the establishment of UCSD), flocked to the area. Collaboration with the military and these defense companies contributed to the rise of high-technology industries in San Diego. Following the end of the Cold War, the demand for defense-related work fell and idle talent formerly linked to the military sector provided a vital labor pool for the life science and biotechnology industries.

Although San Francisco took the lead in the early development of the biotechnology industry, San Diego was home to Hybritech, one of the earliest dedicated biotech firms in the country, founded in 1978 by former Stanford researchers. In 1985 the business accelerator CONNECT was founded in response to the continued growth of high-tech industry in the area with the goal of promoting high-tech businesses by linking entrepreneurs to public research efforts and business support services (including financing).

The continued success of Hybritech led to its acquisition in 1986 by the pharmaceutical company Eli Lilly. Although Hybritech eventually disappeared under Eli Lilly's leadership, former scientists and leaders at Hybritech went on to found numerous spinoff companies and several VC firms in the San Diego area throughout the 1980s and 1990s. Twenty-five years after Hybritech's founding, more than 50 firms could trace their establishment back to Hybritech.[35] The efforts of ex-Hybritech played a key role in the establishment of the biotechnology industry in San Diego.

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[35] DeVol, Ross, et al. "America's Biotech and Life Science Clusters." *San Diego's Position and Economic Contributions. Santa Monica: Milken Institute*(2004).

To summarize, San Diego's current position as a leading life science cluster traces back to presence of strong research anchor institutions. Talent, complementary research and collaboration with the defense industry strengthened basic research strengths which would ultimately support the development of the biotech industry. The unique story of Hybritech and its spinoffs was also an unplanned turn of events which strengthened the industrial cluster.

CONCLUSION

This slow historical development of existing biotech clusters should temper expectations of rapid establishment and growth of new ones. The very nature of the life science and biotech industry constrains the growth rate of clusters. Biotech R&D, for instance, is a long, complex and expensive process. Several years may be spent in the basic and preclinical research stages leading to drug discovery, and the average time needed to achieve FDA approval following drug discovery exceeds 10 years. Only 12% of medicines that enter clinical trials are ultimately approved by the FDA, and the average cost to develop one new drug exceeds $2.6 billion. Thus, even with adequate access to capital, skilled labor, and strong partnerships, biotech clusters should grow gradually.

The case studies presented indicate that there is no single recipe for industrial cluster development. Pharmaceutical companies, for instance, provided an anchor for the development of biotechnology in Philadelphia, while universities and independent research institutes anchored the industry in Boston and San Diego respectively. The presence of these anchors and development of the life science industry more broadly had traced to developments from several decades (in some cases centuries) prior, indicating a path-dependence in cluster development.

However, the recent study and codification by academics and practitioners of the economic development of clusters established in the 20th century may allow aspiring clusters in places like Orlando to fast-forward their development. In addition, the clusters analyzed in this section grew throughout the 1980s and 1990s. Policy driven clusters such as Lake Nona have modern benefits of faster and more efficient communication with partners. Better communication, when combined with more efficient travel methods compared to the 20th century, should increase opportunities for collaboration with other partners and facilitate cluster development. Increased mobility of star scientists should also facilitate cluster development. Florida has a particular advantage in attracting companies and researchers given the low cost of living relative to successful biotech clusters like San Diego, Boston and Philadelphia.

Although the communication and transportation benefits of the 20th century, the relative economic attractiveness of the state of Florida, and the support of local policy makers is likely to facilitate the development of the cluster at Lake Nona, it would be unrealistic to expect a successful cluster to develop overnight. Major clusters have taken decades to develop in the past, and the lack of consideration of the path-dependent nature of cluster development may have produced unrealistic expectations by policy makers regarding the pace of development of the cluster at Lake Nona.

Chapter 4: Venture Capital and the Biotech Industry

This chapter assesses the role of venture capital in supporting the biotech industry, and analyzes how trends in venture capital funding in the past decade may have hindered or supported the development of an industrial cluster at Lake Nona. After clarifying the importance of venture capital for biotech firms, national trends in venture capital funding for the life science and biotech industry are analyzed, and the relevance of these trends for Lake Nona are discussed.

FUNDING FOR BIOTECH STARTUPS

Funding Requirements

Biotechnology is generally viewed as a high-risk industry due to the need for large front-end investments and high rates of attrition throughout a lengthy R&D and FDA approval process. A 2014 study by the Tufts Center for the Study of Drug Development estimated that the average cost needed of gaining FDA approval for a new drug rose by more than 145% within a decade - from $1 billion in 2003 to $2.6 billion in 2013.[36] This figure includes $1.395 billion in out-of-pocket costs and $1.16 billion in opportunity costs. Although Tuft's methods and final number are controversial, the out-of-pocket and total costs are frequently cited by pharmaceutical and biotechnology companies to justify high drug prices and the need for substantial funds from investors.

The out-of-pocket expenditures related to drug development are particularly burdensome for young biotech firms given their inability to support R&D efforts with revenue from other products. The 2015 BDO Biotech Briefing examined 10-K SEC filings

[36] Peters, Sandra. "Cost to Develop and Win Marketing Approval for a New Drug Is $2.6 Billion." *Tufts Center for the Study of Drug Development*. Tufts University, 18 Nov. 2014. Web. 15 Mar. 2016. <http://csdd.tufts.edu/news/complete_story/pr_tufts_csdd_2014_cost_study>.

of publicly traded companies listed on the NASDAQ Biotechnology Index and found that the average annual R&D expenditures of biotechnology firms increased by 18% to $55.6 million. Average revenues increased by 44% during the same period. Large biotech companies (over $50 million in revenue), however, witnessed the majority of this revenue growth, with an average revenue increase of 52% compared to 7% for small firms. R&D as a percentage of revenues for small biotech firms in 2014 rose from 261% in 2013 to 313% in 2014, but fell from 101% to 83% for large firms.

In addition to the high R&D costs associated with drug development, biotech investors must weigh risks associated with a decade-long investment horizon. The total average length of time needed for an experimental drug to navigate the FDA approval process is ten years.[37] On average, only five of every 5,000 (0.1%) of drugs are selected for clinical trials, and, of those selected, only 12% will ultimately receive FDA approval.[38] In stark terms, only 0.012% of identified drugs will receive FDA approval and move on to the marketing stage. FDA approval, however, does not in and of itself guarantee that investors will recover their investment. Only two of every ten drugs that enter the commercialization stage of the innovation pipeline will return revenues that match or exceed R&D costs.[39]

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[37] *2015 Profile: Biopharmaceutical Research Industry.* Washington, DC: Pharmaceutical Research and Manufacturers of America, 2015.Web.
<http://www.phrma.org/sites/default/files/pdf/2015_phrma_profile.pdf>

[38] "The Beginnings: Laboratory and Animal Studies." U.S. Food and Drug Administration, 27 Apr. 2015. Web. 15 Mar. 2016. <http://www.fda.gov/Drugs/ResourcesForYou/Consumers/ucm143475.htm>.

[39] *2015 Profile: Biopharmaceutical Research Industry.* Washington, DC: Pharmaceutical Research and Manufacturers of America, 2015.Web.
<http://www.phrma.org/sites/default/files/pdf/2015_phrma_profile.pdf>

Funding Sources

Clearly, the growth of a new biotechnology firm depends heavily on its ability to access large and long-term investments. However, highly variable returns, a lack of collateral, and information asymmetries between firms and potential investors often limit biotechnology firms' access to traditional debt financing.[40] These same limitations constrain both young and more established (i.e. publicly traded) biotechnology firms. In 2014, for example only 34% of publicly traded biotechnology firms sought debt financing.[41] Biotechnology startups must therefore turn to a variety of grants and equity-based financing options to help launch and expand their operations, including:

- **Grant funding.** A variety of grants are available for biotechnology firms at the federal, state and local government levels as well as from private healthcare foundations. Unlike equity-based financing, grant funding does not demand a return on investment. Grant funding, however, is often limited and targeted at the earliest stages of product development. The Small Business Innovative Research (SBIR) program, for example, one of the most popular funding sources for small biotech firms, coordinates federal grants of less than $1 million only for pre-commercialization development objectives.
- **Angel funding.** High net worth and well-connected individuals with an interest in the biotechnology industry are another source of financing for biotechnology companies. Angel investors typically provide seed funds of less than $250,000 for early stages of development. In 2014 angels invested over $1.65 billion in 870

[40] Carpenter, Robert E., and Bruce C. Petersen. "Capital market imperfections, high-tech investment, and new equity financing." *The Economic Journal*112.477 (2002): F54-F72.
[41] *2015 BDO Biotech Briefing.*. BDO USA, 2015.Web. <https://www.bdo.com/getattachment/8d9c5a19-49d4-473b-889a-595ec0fc5e65/attachment.aspx>

deals, 18% of which were in the healthcare and life sciences sector.[42] Although angel investors seek a high return on their investments, they often demand less involvement in company politics and operations than traditional venture capital firms.

- **Large corporations.** In an increasingly competitive environment, large pharmaceutical companies are outsourcing R&D activities by investing in the innovative research efforts of biotechnology companies in exchange for rights to drugs developed. The majority of pharma-biotech deals are struck during or after the clinical development stage.[43] Licensing and collaboration with pharmaceutical companies provides biotechnology not only with financial resources to support development efforts but manufacturing and marketing expertise for the successful commercialization of a product.
- **Venture capital.** Venture capital has long been a primary source of funding for biotechnology firms. According the PricewaterhouseCoopers data, more than $7.4 billion in venture capital funds were invested in U.S. biotechnology firms in 2015. Venture capital investments are significantly larger than funds obtained through grants and angel investors. In exchange, VC firms receive an equity or ownership stake and actively invest time an energy into steering the development of the firm and ensuring its success. Traditionally, venture capital is provided in later stages of development when products have displayed some potential for commercial success.

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[42] "2015 Halo Report." *Angel Resource Institute*. Williamette University, n.d. Web. 29 Mar. 2016. <http://www.angelresourceinstitute.org/research/halo-report/halo-report.aspx>.

[43] Skripka-Serry, Julia. "Biotech & Pharma 2013 Licensing & Partnering Activity Review." *Bioassociate Industry Blogspot*. Bioassociate Innovate Consulting, 19 Jan. 2014. Web. 15 Mar. 2016. <http://bio-associate.blogspot.com/2014/01/biotech-pharma-2013-licensing.html>.

Although biotechnology firms have access to a range of financing options, the scale of venture capital investments is unmatched by other funding sources. The role of venture capital firms often goes far beyond that of a traditional financial intermediary, and VC firms may serve as an importance source of management expertise for new biotech firms. VCs often require an active role in the target firm's board in order to influence strategy and governance. Among other things, VCs may lend their business expertise to young firms by helping them to develop or refine business and financial plans, develop marketing strategies, and develop contingency plans in the event of failure. This business acumen may be particularly valuable for biotechnology spin-offs, many of which are founded by academics and scientists without a strong business background. Venture capital, therefore, remains a unique and critical funding source for biotechnology startups.

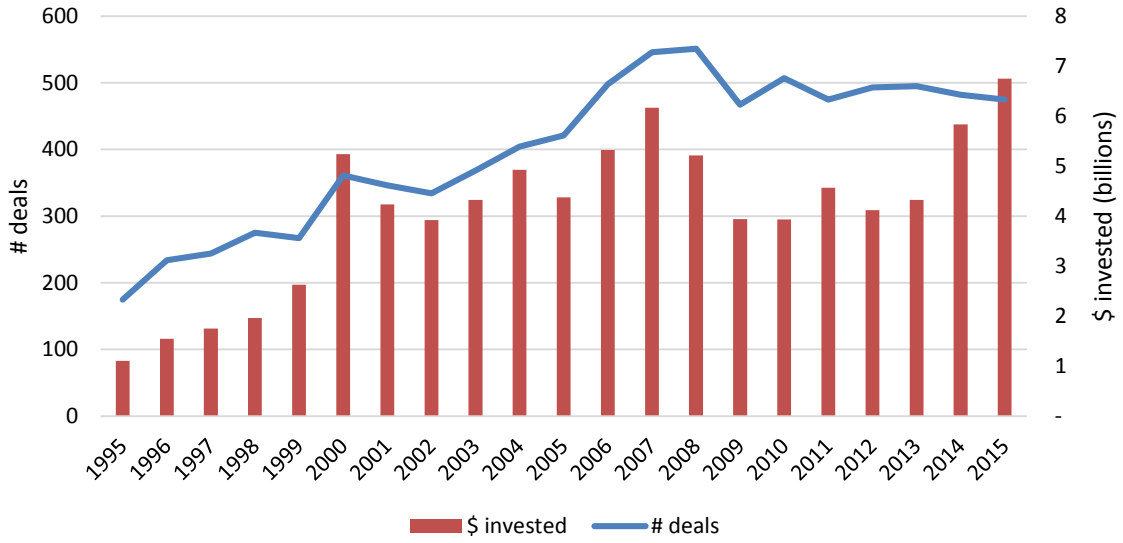
NATIONAL TRENDS IN BIOTECHNOLOGY VENTURE CAPITAL

Following the burst of a "genomics bubble" which paralleled the dot com bubble of 2000, a recovering biotech industry experienced an upward trend in venture capital investment through 2007. In 2008, however, as a result of the financial crisis, venture capitalists and private equity groups scaled back their investments across all industries, including biotechnology. Venture capital investment in the biotech industry continued to fall throughout 2010 as venture capitalists limited their investments and turned their attention towards less risky industries.

Investment in the biotech industry began to recover in 2011, thanks in part to a strong public offering market for biotech firms, and in 2015 venture investment exceeded pre-recession levels. According to the fourth quarter life sciences MoneyTree Report from PricewaterhouseCoopers (PWC), 2015 venture capital funding for biotechnology (and the

life science industry more broadly) was the highest since the start of the MoneyTree data series in 1995. Venture capitalists invested more than $7.4 billion in 475 biotechnology deals in 2015, a 16.8% increase in value over 2014. As seen in Figure 2, this investment level was record-setting levels in both nominal and real (inflation-adjusted) terms.

Figure 2: Annual VC Investment in the U.S. Biotech Industry (constant 2009 $)

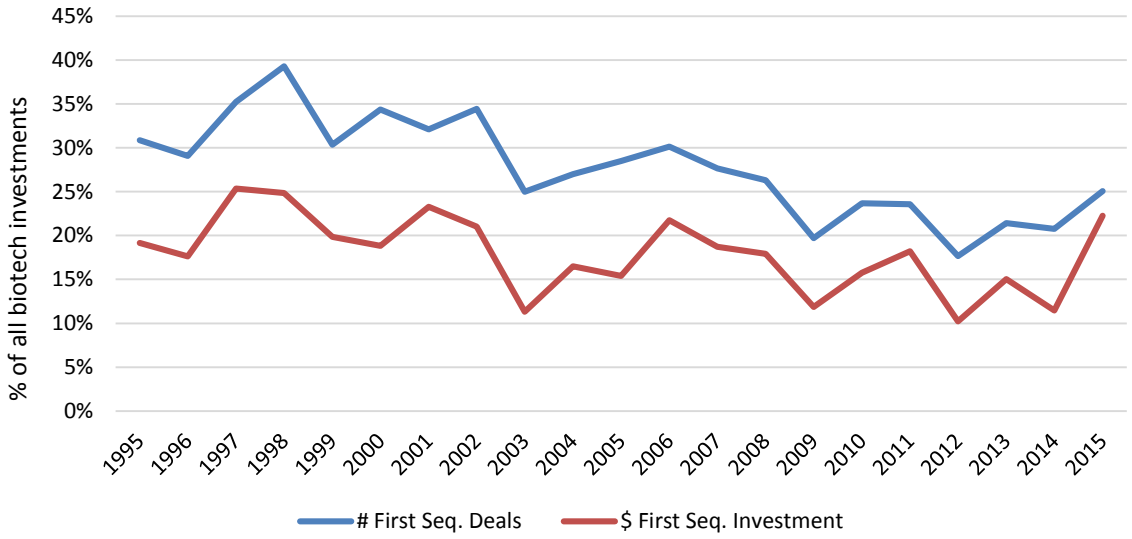


It is important to note, however, that the total number of deals in the industry has remained relatively flat since the recession, implying that surging investment levels are the result of larger rather than more numerous investments. Start-up and early stage companies may find it particularly challenging to secure venture capital funding in such an environment.

The stagnant number of total deals in the industry is particularly concerning for biotech start-ups in light of declining first-time funding. As seen in Figure 3, first-time funding for biotech companies has fallen since the late 1990s, both as a percentage of total dollars invested and of the total number of deals, indicating that venture capital firms are

increasingly focusing their investments on more established biotech firms which have been previously vetted for venture capital funds. Although first-time funding spiked in 2015, it remains to be seen whether this trend will continue in the future.

Figure 3: First Sequence Biotech Investments as a % of Total Biotech Investments

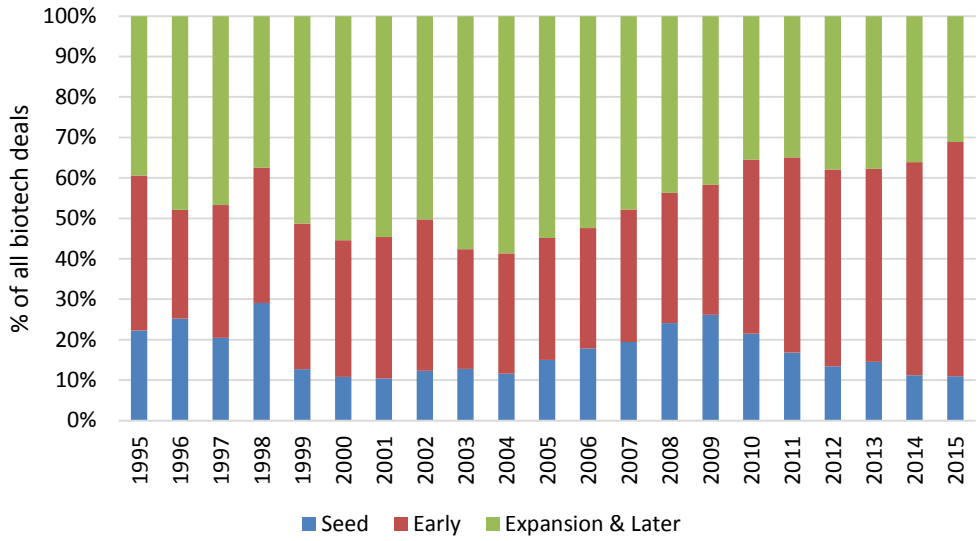


A look at PWC's venture capital funding data by stage of company development provides a more nuanced view of venture firm's investment preferences. PWC classifies companies receiving venture capital as being in either the seed, early, expansion or late stages of development. Because PWC does not provide industry-specific definitions of company development stages, an accurate cross-walk between company development stage (as defined by PWC) and a biotech company's general location along the more industry-specific innovation pipeline cannot be established. In general, however, life science investors consider products in the preclinical testing stage to be early-stage

investments, while companies whose products have been selected for the clinical stage or are already being marketed are considered in the later stages of development.[44,45]

As seen in Figure 4, seed stage venture investments in biotech have fallen steadily as a percentage of total deals since the Great Recession. In 2009, 122 seed stage investments worth $713.6 billion were made, compared with only 52 investments worth $452.9 billion (inflation-adjusted dollars) in 2015 – a decline of nearly 37% in value and 57% in volume.

Figure 4: VC Deals by Stage of Company Development



Clearly, investor preference for the most nascent of biotechnology companies has waned. Investor interest in more established biotech firms has also fallen. The share of investments made in companies in the expansion and later stages of development has

[44] Fleming, Jonathan J. "The decline of venture capital investment in early-stage life sciences poses a challenge to continued innovation." *Health Affairs* 34.2 (2015): 271-276.

[45] Seed funding will be understood to be particularly valuable to new biotechnology startups, as funding may support not only preclinical research and development but discovery research.

shrunk slowly as a percentage of total deals over the last decade, falling from 59% of all deals in 2004 to 31% of all deals in 2015. Instead, investor interest and resources since the Great Recession have shifted towards early-stage biotechnology companies. In 2015 58% of all biotechnology venture investments flowed towards early-stage companies compared to 32% in 2009.

In sum, while the average venture investment made in the biotech industry has risen dramatically in the past few years, the total number of investments has remained flat. This stagnation, combined with falling first-time funding within the industry, implies that investors are sticking with biotechnology firms in which they have previously invested. These follow-up funds seem to be directed at early stage firms which have likely not yet reached the commercialization stage of the innovation pipeline or begun to see significant revenue growth. Companies in the earliest stages of development (i.e. seed) are a falling priority for investors. In this environment, new biotech start-ups may find it difficult to gain traction by securing venture funding.

IMPLICATIONS FOR LAKE NONA

As venture capital firms lowered the risk-level of their biotech portfolios after the Great Recession by decreasing seed stage and first-time venture funding, post-recession startups would have relied more heavily than normal on alternative early funding sources. However, the Great Recession also impacted funding available from other early stage investors. Funding provided through NIH grants, for example, plunged during the Great Recession and has only begun to rebound in the last year or two.

Given the large up-front costs of biotech R&D research, such constraints on early stage funding may have naturally limited the ability of collaboration at Lake Nona to yield

spin-off companies. Rebounding public funding will play an important role in supporting innovative discovery research at Lake Nona which may ultimately result in applied research at a spin-off company. However, in light of venture firms' preference for funding more established biotech startups which have moved beyond the seed stage of development, policy makers have an important role to play in ensuring companies have funding available to help them move from basic to preclinical research.

At the federal level, the funding for Phases I and II of the SBIR should be increased to ensure increased funding for basic research. NIH funding, which has fallen in real terms every year for the past decade, should be increased for similar reasons (see Chapter 5 for a more in depth discussion regarding NIH funding and relevance for Lake Nona). Other researchers have suggested that the FDA create a unique testing route for biomedical and pharmaceutical compounds which would allow for earlier demonstration of product efficacy to attract funding earlier.

States may also play a role in promoting greater and earlier venture capital investments. The State of New York, for instance, has led the development of a unique venture capital funding pool by contributing state funds alongside pharmaceutical companies and venture capitalists. The collaborative venture capital pool may have the added benefits of overcoming local investment preferences of VC firms and encouraging corporate venture capital investment (a growing trend within the VC industry).

Overall however, despite efforts by policymakers, Florida has remained a minor player in the venture capital scene and has failed to increase its relative proportion of national venture capital funds. The influence of the Great Recession on venture capital made it even more difficult for Florida biotech firms to secure VC funding. Barring dramatic shifts in the risk-tolerance of the venture capital industry, aspiring clusters like

Lake Nona will continue to face a challenge in attracting adequate venture capital in order to fuel the commercialization of biomedical discoveries.

Chapter 5: NIH Funding

In recognition of the importance of NIH funding in fueling basic research efforts of a biotechnology cluster, this chapter analyzes trends in NIH funding over the past decade and the implications of these trends for the development of the Lake Nona cluster.

AN UNTIMELY CRISIS

The National Institute of Health is the largest single source of support for biomedical research in the United States, accounting for four-fifths of U.S funding for federally funded life sciences research. NIH funding is typically provided in the form of grants to scientists working at universities and institutions. NIH funding (and federal funding more generally) are particularly critical for the basic research stage of the biomedical and life science innovation pipeline, as private funders such as angel investors and venture capitalists typically provide financial support once a product or business idea has materialized and a return on their investment can be foreseen.

In 1998, Speaker of the House Newt Gingrich and President Bill Clinton secured bipartisan support to substantially increase federal spending in biomedical research.[46] Political and popular support of biomedical and life science research stemmed from a number of scientific developments in the area (including cancer treatment) as well as a strong economy and healthy debt levels. Funding for biomedical and life science research continued to rise over the next decade and, in 2005, at the time that key partners were committing to Lake Nona and the biomedical cluster was beginning to take shape, NIH funding for biomedical research was close to an all-time high.

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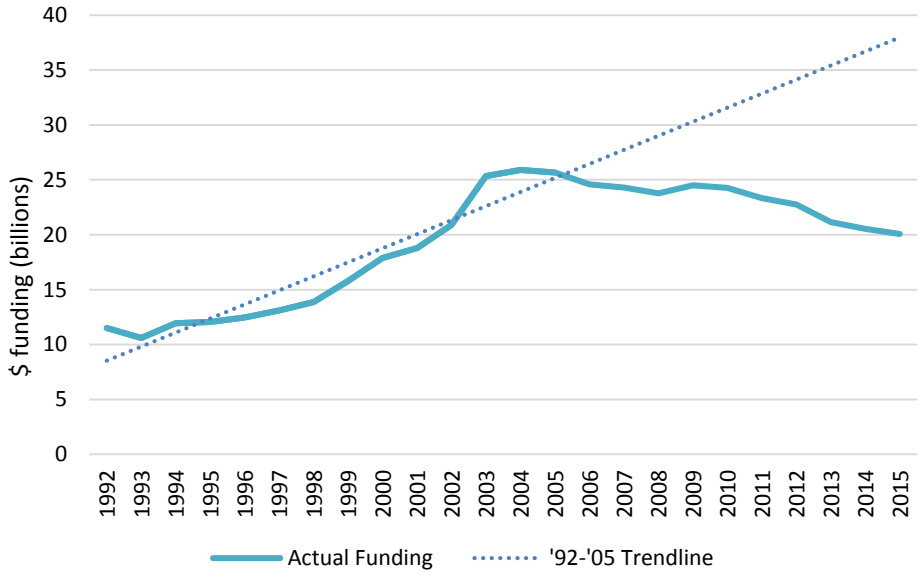
[46] Pear, Robert. "Government Ready to Boost Spending for Biomedicine." *The New York Times* [New York, New York] 3 Jan. 1998: n. pag. *The New York Times*. Web. 20 Mar. 2016. <http://partners.nytimes.com/library/politics/010398clinton-budget.html>.

Much of the excitement surrounding Lake Nona would have rested on the promise of federal funding for cluster partners who would be engaged in basic research, including UCF and Sanford Burnham. Indeed, the Sanford Burnham Institute as a whole consistently ranks among the top four institutes with respect for NIH funding and it would have been reasonable to expect that they would continue to attract funding for their work in Orlando. In sum, the rapid development of the cluster at Lake Nona rested heavily on basic research funding from the NIH to support the research efforts of star scientists and their subsequent efforts to commercialize their discoveries through research.

Unfortunately, the leaders of Lake Nona could not have foreseen the beginning of the financial crisis or the Great Depression, which had a devastating impact on NIH funding. As shown in Figure 5, annual NIH funding has declined consistently since 2005. Funding levels in 2015 were approximately 20% below peak funding levels in 2005 (this graph excludes funding from the temporary American Reinvestment and Recovery Act).

Figure 5: Annual NIH Funding (constant 2009 $)



It may be argued that the simple difference in real funding, however, does not reflect the full impact of the fall in funding for Lake Nona scientists had partners expected NIH funding trends to continue. A better comparison might be actual funding against funding levels which might reasonably have been expected by Lake Nona founders in 2005. The trend line incorporated in Figure 5 reflects funding levels Lake Nona partners and leaders could reasonably have expected had funding continued to increase according to historical trends. As can be seen in the graph, actual funding in 2015 (approximately $20 billion) was nearly 85% lower than would have been anticipated by historical trends. Such a downturn in NIH funding would have slowed the progress of Lake Nona partners in meeting employment and research goals initially drafted at the height of basic research funding in 2005.

FUTURE PROSPECTS FOR NIH FUNDING

Because of the importance of NIH funding in fueling basic research at Lake Nona, it is important to consider future funding prospects. Importantly, Congressional support for NIH funding seems to be returning. In 2016 Congress approved a $2 billion increase in NIH funding to $32.1 billion, effectively halting a decade long decline in funding. This support represented an increase of 6.6% over 2015 funding levels and was the largest increase in funding that the NIH has received from Congress since 2002.[47] This funding increase exceeded the President's request of a $1 billion increase in funding for the agency, underscoring that biomedical research has returned as a priority for policymakers and the public more broadly.

In order to gain a better understanding of the future prospects for funding in the biotech sector, I interviewed Dr. David Denslow. Dr. Denslow is a retired researcher from the Department of Business Economics at the University of Florida, and has a focus on and expertise in economic development within North Central Florida. In Dr.Denslow's opinion, there are several reasons for optimism regarding the future of biotech, including:

- **Advances in technology.** Unprecedented progress and discoveries in the life sciences is likely to pique the interest and support of the public and policymakers. Advances in research technology range have forwarded the development of personalized medicine and raised the promise of improved quality of life. Recent advances in Alzheimer's research, for instance, may have played a role in the $350 million increase in funding for research of the disease as part of the recent NIH funding increase.

[47] Mervis, Jeffrey. "Updated: Budget Agreement Boosts U.S. Science." *Science Mag*. N.p., 18 Dec. 2015. Web. 20 Mar. 2016. <http://www.sciencemag.org/news/2015/12/updated-budget-agreement-boosts-us-science>.

- **Research spillovers.** Dr. Denslow cited a recent economic study which demonstrated that nearly half of the patents resulting from NIH funding for a particular disease were associated with other diseases. The same study also showed that public R&D funding may actually increase rather than decrease private R&D funding.[48]
- **Demographics.** As the aging baby boomer generation raises the average age of the U.S. population, the value of good health to the public rises and spending on life sciences should rise proportionally. As the population ages, federal spending on health care programs and research is likely to rise proportionally. The Congressional Budget Office (CBO), for example, has estimated that annual spending on major health care programs is likely to double in the next decade, rising from $936 billion in 2015 to $1,835 billion in 2026.

CONCLUSION

This chapter analyzed trends in NIH funding given the importance of federal funding for basic biomedical and life science research. Partners at Lake Nona would have relied heavily on this funding source, and successful basic research ultimately would have formed the basis for the formation of spinoff companies.

At the time Lake Nona was formed, federal funding for the life sciences was at an all-time high. However, funding plummeted following the Great Recession. This unexpected fall would have directly limited the basic research efforts of key Lake Nona partners, effectively constraining the growth of the cluster and preventing them from achieving research and employment goals formed on the basis of trends through 2005.

[48] Hunter, Philip. "More is less." EMBO reports 8.7 (2007): 626-628.

A recent rebound in funding and interest for the life sciences, however, may be a game changer for Lake Nona. Although this rebounding interest is recent, macro trends including an aging population and advances in technology are likely to sustain support for the biotech industry and the prospects for the successful formation of a biotech cluster at Lake Nona.

Chapter 6: The UCF College of Medicine

The UCF College of Medicine was established in 2009 and was considered an anchor institution critical to the development of the Lake Nona cluster. Indeed, a 2006 study by the Milken Institute – often cited by Lake Nona supporters and visionaries – centered its economic impact estimates of the envisioned cluster around the College of Medicine. This chapter analyzes the successes and challenges of the new college in assessing whether the college has succeeded in catalyzing the development of Lake Nona as anticipated.

CONTRIBUTION OF MEDICAL SCHOOLS TO LIFE SCIENCES CLUSTERS

Universities often serve as anchors for research-intensive industry clusters; collaboration with university-based scientists allows partners to access research funding and core facilities, while a steady stream of university graduates provides access to a pool of highly skilled labor. Given that life science research is complemented by innovations across disciplines, firms in the life science and biotech industry benefit from proximity to a range of university departments. Research-based colleges of medicine, however, play a particularly important role in fostering the development of life science clusters by providing access to infrastructure, funding and human capital unique to the biomedical sciences.

Physical Infrastructure

Among other things, a college of medicine provides access to specialized research facilities, equipment (e.g. wet laboratory space) and technicians. State-of-the-art university facilities help to attract and retain successful "star scientists" who, in turn, compete for federal grants and other research funding. Institutions with more research space are able to

hire more investigators and thus produce more research. Given that the number of NIH grantees, total federal grant funding and other metrics of research volume are often used in ranking systems, the expansion of research facilities may correlate directly with an institution's ability to move up within ranking hierarchies.

University research facilities also serve as a resource for research partners and private firms in the surrounding region. In their annual reports on life sciences industry clusters, Jones Lang LaSalle (JLL) uses laboratory space as a key factor in assessing the promise and relative strength of life science clusters throughout the world. Although trends within the industry are increasing demand for specialized lab space and driving up rent prices in major clusters, life science firms remain entrenched in traditional geographic clusters given their need for R&D infrastructure and specific labor pools.[49] However, JLL predicts that in the medium to long term these rising rent prices could push large life science firms to seek secondary markets outside of traditional large clusters. Ensuring that laboratory and incubator space is available at Lake Nona within College of Medicine facilities and the Guidewell Innovation Center will place Orlando within the consideration set of firms making such a move.

R&D Funding

A university's ability to attract R&D funding is widely considered a measure of its academic strength; strong R&D infrastructure attracts "star-scientists" who enhance not only the research volume but research quality of a university. The overall level of R&D expenditures institutions within a region can be viewed as an indicator of a region's ability to innovate, encouraging both academic and non-academic funding recipients to undertake

[49] *Life Sciences Outlook*. Rep. Jones Lang LaSalle, n.d. Web. 25 Mar. 2016. <http://www.us.jll.com/united-states/en-us/Documents/Life-Sciences/JLL-US-Life-Science-Outlook-2015.pdf>.

and commercialize innovative research.[50] Strong R&D infrastructure is critical to any region seeking to strengthen a life science industry.

Colleges of medicine attract R&D funding to a region. A 2006 study by the Milken Institute found that the median annual R&D expenditures of universities with associated medical schools were nearly three times those of universities without medical schools - $224.8 million compared to $75.3 million.[51] Furthermore, the median annual R&D expenditures by universities with medical schools located in life science clusters – such as San Diego, Raleigh-Durham, San Francisco and Philadelphia – was nearly $100 million more than by universities with medical schools *not* located in clusters.

Human Capital

A research-based college of medicine attracts human capital critical to the life science industry.[52] Star scientists (as measured by research output) play a separate and even greater role than well-ranked universities in fostering the development of biotech industry clusters. As mentioned above, these star scientists may be attracted by the opportunity to conduct research in state-of-the-art facilities within medical schools that provide them access to equipment and skilled technicians for their research. They may also be attracted by the opportunity to teach at a medical school or participate part time in a clinical practice at a hospital.

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[50] DeVol, Ross, et al. "California's Position in Technology and Science." *Milken Institute: Santa Monica* (2004): 86.

[51] Wong, Perry, and Armen Bedroussian. "Economic Benefits of Proposed University of Central Florida College of Medicine." *Santa Monica, CA: Milken Institute* (2006).

[52] Zucker, L. G., M. R. Darby, and M. B. Brewer. "Intellectual human capital and the birth of US biotechnology enterprises. American Economics Review 88 (1) 290–306." *Intellectual Capital and Financing Decisions: Evidence from the US Patent Data* 23 (1998).

A strong college of medicine serves to attract human capital beyond university-based scientists. Individuals tend to marry others with similar characteristics as themselves such as age, education, religion, income, and even physical characteristics such as weight and height – a phenomenon known as "assortative mating".[53] Healthcare and bioscience clusters such as Medical City can capitalize on this phenomenon by using it as an opportunity to attract more qualified professionals for hire. Medical City at Lake Nona already offers a centralized job search protocol, making it easier for spouses to identify jobs within the cluster and to co-locate. Sanford Burnham president and CEO John Reed noted that "the presence of a cluster makes it easier to find a workplace for professional-level spouses who frequently work in related fields — a surgeon, for example, married to a researcher."[54]

Not to be overlooked are the medical school graduates themselves. Physicians engage in a variety of activities that enhance the agglomeration effects of life science clusters, including relaying patient medical needs and priorities to researchers, spearheading technological innovation (e.g. medical devices[55]), enrolling patients in clinical trials, consulting and giving lectures. Physician-scientists (researchers with either M.D. or M.D.-Ph.D degrees) are a uniquely valuable component of the biomedical workforce, using insight from clinical practice to guide relevant basic discovery research and innovation. Deborah German, dean of the UCF College of Medicine, noted the

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[53] Chiappori, Pierre-André, Sonia Oreffice, and Climent Quintana-Domeque. "Fatter attraction: anthropometric and socioeconomic matching on the marriage market." *Journal of Political Economy* 120.4 (2012): 659-695.

[54] Howard, Mark R. "Medical City Is Changing Florida's DNA." Florida Trend, 1 Oct. 2009. Web. 27 Mar. 2016. <http://www.floridatrend.com/article/4984/medical-city-is-changing-floridas-dna>.

[55] Chatterji, Aaron K., et al. "Physician-industry cooperation in the medical device industry." *Health Affairs* 27.6 (2008): 1532-1543.

importance of having both research and clinical foundations, saying that *"*You don't want a faculty that practiced medicine 20 years ago, or worse, never practiced at all."[56]

While the quality of human capital is important, the sheer number of scientists, practitioners, physicians associated with a college of medicine also has implications for research productivity. Using a natural experiment in NIH funding during the recession, analysts found that research projects with a larger team size (as measured by the number of authors) generated more and higher-impact research (as measured by citation rates) that was less likely to fail.[57] Similarly, a 2006 study by the Milken Institute found that, of the top 20 universities ranked by publication output, only one – Rockefeller University - lacked a medical school. Rockefeller University does, however have a medical training program with an affiliated hospital and an M.D./Ph.D. program with the Graduate School of Medical Sciences at Cornell University.[58]

Adapting to New Research Norms

The presence of a college of medicine may also help universities adapt to the changing trajectory of biomedical innovation. The traditional view of the progress of biomedical research - beginning with basic research, followed by applied research and finally by commercialization - may no longer hold. Learning through clinical practice and technological advancement, for instance, may yield advances in medical diagnosis and treatment independent of new discoveries made through basic research.[59] Advances made

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[56] "Lake Nona's Medical City." Spacecoast Business, Apr. 2014. Web. 29 Mar. 2016. <http://www.spacecoastbusiness.com/lake-nonas-medical-city/>.

[57] Park, Hyunwoo, Jeongsik Jay Lee, and Byung-Cheol Kim. "Project selection in NIH: A natural experiment from ARRA." *Research Policy* 44.6 (2015): 1145-1159.

[58] DeVol, Ross C., et al. *Mind to market: A global analysis of university biotechnology transfer and commercialization*. Santa Monica, CA: Milken Institute, 2006.

[59] Nelson, Richard R., et al. "How medical know-how progresses." *Research Policy* 40.10 (2011): 1339-1344.

in non-medical disciplines, including physics, material sciences, mathematics and engineering are increasingly important and frequently adapted for biomedical use. In addition, universities have been increasingly involved in commercialization activities since the Bayh-Doyle Act of 1980 allowed them to own the patents arising from their federal research grants rather than assign ownership to the government. Such a blurring of lines has altered the role of government, universities, private research institutes and the private sector in the trajectory of innovation.

In light of these changes, universities are expanding their roles beyond that of basic research. The presence of a college of medicine enables a university to position itself for more translational (i.e. basic to clinical) research by providing access to physicians and patients and provides local partners like Sanford Burnham with more opportunities to collaborate with clinical faculty. A college of medicine also provides universities with an edge in product commercialization by attracting star scientists likely to engage in academic entrepreneurship.

UCF COLLEGE OF MEDICINE

The UCF College of Medicine was considered critical for the development of the Lake Nona biomedical cluster. Several key partners chose to locate to Lake Nona only after the College of Medicine's presence was secured. The establishment, successes and challenges faced by the new school of medicine are explored in the sections below.

Establishment

UCF President John Hitt had long been focused on transforming the Orlando economy and diversifying away from its dependence on tourism by developing biotech research capability within the region. This focus complemented a larger statewide push for technology of the biotechnology industry in Florida begun by the Florida Legislature and Governor Jeb Bush. Ironically, a medical school was not part of Hitt's vision until he learned of the range of benefits provided by a college of medicine. That information led him to state that "you don't find a biotech cluster around anything but a medical school".[60]

The structure of the life sciences industry in Orlando prior to 2009 was poised to benefit from the presence of a new college of medicine. In 2006 Orlando's life science sector was comprised mainly of medical-device manufacturing firms, with 17 of the top 20 life science firms engaged primarily in life-science manufacturing.[61] Orlando was also home to the Burnett Biomedical Research Center and to a large health-care system that included Florida Hospital and Orlando Regional Healthcare. The UCF College of Medicine was expected to capitalize on the growing relationship among academic, research and clinical practice by collaborating with this already strong life science base.

A 2006 Milken Institute study quantified the anticipated impact of the UCF College of Medicine on the greater Orlando economy. Compared to baseline projections, the college of medicine was expected to have a minimum economic impact of $1.4 billion and create more than 6,000 jobs. In the event that the College of Medicine triggered the growth

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[60] Howard, Mark R. "The Keys to Medical City." Florida Trend, Oct.-Nov. 2009. Web. 29 Mar. 2016. <http://www.floridatrend.com/article/4985/the-keys-to-medical-city>.

[61] "Lake Nona's Medical City." Spacecoast Business, Apr. 2014. Web. 29 Mar. 2016. <http://www.spacecoastbusiness.com/lake-nonas-medical-city/>.

of the Orlando life sciences industry in a pattern resembling established clusters, its economic impact was predicted to be more than $6.4 billion and more than 25,000 jobs.

In 2005 the Tavistock Group, an international investment organization, fast forwarded the development of a medical school in Orlando by donating 50 acres at its Lake Nona complex and $12.5 million. Combined with locally raised funds and a matching grant from the state, UCF received well over $100 million in support, and in March 2006 the Florida Board of Governors approved UCF's proposal to build a college of medicine. The UCF College of Medicine opened its doors to its first class in August of 2009.

Successes to Date

The announcement of the medical school quickly prompted the hoped-for clustering effects. As soon as the College of Medicine was approved in 2006, Sanford Burnham announced its intention to expand operations to Lake Nona. The presence of a College of Medicine played a key role in this decision. *"*History has shown that successful biotech hubs have at their core a medical school, which drives scientific exchange and the pursuit of knowledge*,"* noted Dr. John Reed, president and CEO of Sanford Burnham Institute, in a release. "The presence of the UCF medical school was an extremely important factor in our decision to locate our East Coast campus at Lake Nona."

The decision of Sanford Burnham and other partners to locate next door to the College of Medicine at Lake Nona was motivated by the highly localized nature of knowledge spillovers. Recent research has demonstrated that the benefits of knowledge spillovers are strongest within five miles or less, and diminish rapidly with distance.[62] Also, given the complicated nature of biotechnology discoveries, tacit knowledge is often

[62] Buzard, Kristy, et al. "Localized Knowledge Spillovers: Evidence from the Agglomeration of American R&D Labs and Patent Data." (2015).

embodied in individual scientists, and requires short-distance or face-to-face interactions for successful knowledge transfer.[63] The geographic proximity of Sanford Burnham and other partners to the medical school at Lake Nona allows them the proximity and opportunities to interact with researchers at the College of Medicine in order to gain the benefits of knowledge spillovers.[64]

The Lake Nona clustering effect continued beyond Sanford Burnham, as a series of major partners announced their intention to join Lake Nona alongside the UCF College of Medicine and Sanford Burnham. The Department of Veterans Affairs, which had considered several sites for the construction of its first new hospital since 1995, finalized its decision to locate at Lake Nona soon after Sanford Burnham.[65] Nemours Children's Hospital, which had already purchased land for a hospital elsewhere, changed its mind within months of these announcements and in 2007 revealed its intention to build a pediatric center at Lake Nona.[66] A commitment from the M.D. Anderson Cancer Center followed that same year, and in 2008 the University of Florida announced plans to locate an academic and research facility at Medical City.

The UCF College of Medicine received over 4,300 applications for 41 positions in its charter class, making it the most selective medical school in the United States at that time. This initial class had the highest MCAT score (32.2) and GPA (3.8) of any incoming

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63 Zucker, Lynne G., Michael R. Darby, and Jeff S. Armstrong. "Commercializing knowledge: University science, knowledge capture, and firm performance in biotechnology." *Management Science* 48.1 (2002): 138-153.

64 Carlino, Gerald A., and Jake K. Carr. "Clusters of knowledge: R&D proximity and the spillover effect." *Business Review* Q3 (2013): 11-22.

65 "House OKs VA Hospital at Lake Nona." Orlando Business Journal, 13 Sept. 2006. Web. 30 Mar. 2016. <http://www.bizjournals.com/orlando/stories/2006/09/11/daily29.html>.

66 Boyd, Christopher. "Nemours Adds Lake Nona to Its List." Orlando Sentinel, 7 Oct. 2006. Web. 30 Mar. 2016. <http://articles.orlandosentinel.com/2006-10-07/news/NEMOURS07_1_nemours-children-hospital-florida-hospital>.

class of medical students in Florida.[67] The flood of applications was due in part to the fact that every member of the inaugural class was guaranteed a full scholarship, including tuition and living expenses. However, acceptance continued to remain competitive for future classes, which were not offered such benefits. UCF received a record 4,875 applications for the recently accepted Class of 2019 – even more than it received for the charter class.

Challenges to Date

Despite initial success in promoting clustering at Lake Nona and the competitive profile of its medical students, UCF's College of Medicine has been slow to solidify its reputation and expertise in biomedical research. It remained unranked in U.S. News' 2016 ranking of medical schools in both research and primary care categories, implying that it was in the bottom 25% of both categories. The college gained accreditation only in February of 2013, just before the graduation of its first class.

Funding for UCF was also slow to launch. Additional NIH Funding attracted by the college, for example, has been minimal. Through 2007 the NIH Research Portfolio Online Reporting Tool reported "Overall Medical" funding for the University of Central Florida – although it is unclear which departments this funding is associated with, it is not directly associated with the College of Medicine which was not even approved until 2006. Beginning in 2008, NIH began reporting funding directly associated with the College of Medicine and the "Overall Medical" funding category disappeared. It can be reasonably assumed, then, that the College of Medicine funding amounts included grants which would prior of fallen under "Overall Medical" funding. The ability of the College of Medicine,

[67] "No. 1 UCF Story of the Decade: College of Medicine." *UCF Today*. University of Central Florida, 3 Aug. 2009. Web. 30 Mar. 2016. <http://today.ucf.edu/no-1-ucf-story-of-the-decade-is/>.

therefore, should be viewed as the difference between "Overall Medical" funding trends and funding formally listed under the "College of Medicine" beginning in 2008. Importantly, this difference is minimal. In 2007, for instance, "Overall Medical" funding for UCF totaled $4.7 million. In 2008, the amount associated with the College of Medicine was $5.5 million – a difference of only $0.8 million. This funding level increased slowly through 2011, and has fallen since. In 2015, for instance, total NIH funding for the UCF College of Medicine was a mere $3.5 million. Clearly, the College of Medicine has been slow to attract research funding.

This limited research is not surprising, however, given how new the college is. The Burnett School of Biomedical Sciences (which was subsumed by the College of Medicine), did provide a foundation of biomedical expertise and resources for the College of Medicine, but was itself only established in 2004. Indeed, although the UCF College of Medicine is expected to serve as the anchor for Medical City, the college itself depended on collaboration with strategic partners to accelerate its transition from a nascent to a strong research-oriented medical school. These partners, however, were slow to cement their presence at Medical City, possibly delaying the college's ability to catalyze the life science industry at Medical City and in the Orlando region more broadly. Despite the initial flurry of activity in 2006 as partners announced their intentions to locate to Lake Nona, nothing actually opened until 2009. The College of Medicine itself - although it welcomed its first class in 2009 - did not open its building to students until a year later in 2010. The Burnett School of Biomedical Sciences, M.D. Anderson and Sanford Burnham were the first of the key Medical City partners to open in 2009.[68] Nemours Children's Hospital and the UF Academic and Research Center did not open until late 2012, more than four years after

[68] Because of ties with another hospital in Florida, which located downtown instead of in Medical City, MD Anderson no longer has a physical presence at Lake Nona.

their commitments. The huge VA hospital, which broke ground in 2008 and was initially expected to be completed in 2012, still is not fully operational (although some services opened in 2015).[69] The timeline below outlines the commitments and opening of key partners at Lake Nona.

Table 3: Timeline of the Development of Lake Nona

2006	Florida Board of Governors approves UCF medical school
	Sanford Burnham announces intention to open office at LN
2007	Nemours announces its intention to locate at LN
	Veterans Affairs announces intention to build new VA hospital
	MD Anderson commits to locate at LN
2008	UF announces intention to open academic and medical facilities
2009	UCF College of Medicine welcomes first class
	Sanford Burnham Institute officially opens
	MD Anderson opens
2010	College of Medicine building opens
2011	-
2012	Nemours Children's Hospital Opens
	UF academic and research centers open
2013	-
2014	-
2015	MD Anderson leaves Lake Nona
	VA begins operating some services, though is not fully operational

[69] "Orlando VA Hospital Opens Years Behind Schedule." WESH.com, 26 May 2015. Web. 30 Mar. 2016. <http://www.wesh.com/health/dedication-planned-for-new-orlando-va-hospital/33202944>.

PROSPECTS FOR FUTURE PERFORMANCE

UCF's focus on building the academic infrastructure for a preeminent medical school, an unexpected drop in R&D funding in light of the Great Recession, and the slow progress of some partners in cementing a physical presence at Lake Nona may have limited the development of the college as well as the extent of its interaction with the life science industry in Orlando. Future collaboration, however, is likely to be more productive. The recent accreditation of the College of Medicine, for instance, is likely to attract higher skilled medical students now that applicants can be certain they will graduate with a degree that will translate to the workplace. Rebounding levels of NIH funding will serve to fuel the activities of researchers within the college. As UCF builds its reputation, it will exert an additional pull for new/smaller life science firms concerned with overcoming the "liability of newness" by benefiting from the legitimacy spillovers of a reputable college of medicine.

Other partners key to the success at Lake Nona are finally establishing a physical and research presence. The VA Hospital, for instance, began offering a limited set of services in 2015 and is expected to fully open in 2016. As partners cement their presence at Lake Nona collaboration is likely to increase. UCF is also taking extra steps to encourage the development of Lake Nona by locating all of its allied health efforts at the cluster, including moving the dental and nursing school. Their presence will further provide a strong opportunity for synergistic research and collaboration for the College of Medicine.

As the national and state economies continue to recover from the Great Recession, the College of Medicine can also look forward to increasing funding for basic research efforts. In 2016, for instance, bipartisan support for biomedical research led to an increase in total appropriations for NIH of $2.2 billion – a 12% increase over 2015 funding levels

and the largest increase in appropriations in over 10 years (refer to Chapter 5 for detailed discussion on NIH funding trends and opportunities).

In sum, although a College of Medicine was considered crucial to the successful development of Lake Nona, the slow development of the new school has likely stunted the development of the cluster as a whole. As other partners at Lake Nona independently gain strength and biomedical funding rebounds, supporters of the Lake Nona development may have grounds to hope that the college will prove to be the catalyst it was anticipated to be in early studies by the Milken Institute. There is, however, no assurance of such a recovery and if the College remains weak it will be much to the detriment of the hoped-for cluster.

Given the slow development, Lake Nona's development has rested more heavily than expected on the initiatives and research of other key partners such as the Sanford Burnham Institute. Given the increasingly interdisciplinary nature of biotechnology and life science research, the UCF system as a whole would have played an important role in providing the benefits of an academic anchor institution for the cluster. The next section will analyze the strengths of the UCF system as a whole in understanding whether the university has been a strong complementary partner for the Lake Nona complex as it waits for the College of Medicine to gain strength.

Chapter 7: Strength of the University of Central Florida

Given the slow start of the UCF College of Medicine, the role of UCF system more broadly in fostering a biomedical cluster at Lake Nona was more important than originally anticipated. This chapter looks at the quality of the UCF system (by analyzing rankings) and funding strength in order to understand whether the university has been a strong partner over the past decade which could have compensated for a lack of resources Lake Nona supporters would have viewed as critical – including NIH funding, venture capital funding, and the UCF College of Medicine.

INTRODUCTION

While the presence of a strong medical school is an important complement to the development of biotech clusters, clusters also benefit from having access to the university system more broadly. Given the slow development of the UCF College of Medicine as a research partner, as described in the previous section, Sanford Burnham may rely more heavily than anticipated on agglomeration benefits provided by the UCF system as a whole. The following sections analyze the academic standing of the UCF with respect to funding as well as funding trends and prospects in order to understand its potential to support through collaboration the research efforts of Sanford Burnham and at Lake Nona.

Medical research in the US began to organize itself closer to university communities in the 1950s as the life sciences became increasingly complemented by innovations in the physical sciences, engineering and computer sciences.[70]. Medical devices and new manufacturing practices for large-molecule bio-pharmaceuticals, for

[70] Rosenberg, Nathan. "Some critical episodes in the progress of medical innovation: An Anglo-American perspective." Research Policy 38.2 (2009): 234-242.

instance, are heavily driven by engineering advances, which depend more on the physical sciences and less on the biological sciences. X-rays, electron microscopy, endoscopy and the CT scanner are but a few examples of medical technologies that emerged from research in physics. In addition, a strong undergraduate population provides clusters with access to high skilled labor, university faculty often serve as consultants in biotech firms and innovations outside of medical research are resources for biotechnology clusters.

RANKINGS

Although the methodologies of rankings systems vary and are imperfect, they provide a useful independent third party assessment of UCF's strengths across disciplines. Student-oriented rankings were de-emphasized in favor of academic rankings, including the ARWU (Shanghai), Leiden, and MUP. U.S. News rankings are also analyzed briefly given their popularity.

Although the ranking systems referenced in this paper differ widely in their methodologies, several patterns emerge. UCF is consistently ranked among the top 300-400 universities in the world and among the top 100-150 universities nationally. Field specific rankings demonstrate a relative strength in the physical and engineering sciences and, to a lesser extent, in the social sciences. While ARWU, Leiden and U.S. News rankings indicate that the quality of UCF's research in the biomedical and health fields remains relatively weak in comparison to other universities, the Leiden rankings show that the quantity of research in this area has been increasing slowly. Although UCF tends to rank low on indicators of faculty prestige, its undergraduate population is of high quality and improving.

ARWU Rankings

The Academic Ranking of World Universities (ARWU), commonly referred to as the Shanghai Ranking, is a global ranking of universities produced annually since 2003 by the Center for World Class Universities of Shanghai Jiao Tong University. Over 1,200 universities are ranked by ARWU every year, and the overall ranking of the top 500 universities are published. The exact ranking of the top 100 universities is provided, while a ranked range is provided for the other 400 top institutions. Impressively, UCF has consistently earned a place among ARWU's top 500 universities since 2003, rising steadily in both global and national rankings from 2003 through 2013, with a small dip in its ranking in the last two years.

Table 4: UCF Placement in Annual ARWU Rankings

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
World Rank	401-500	404-502	401-500	301-400	305-402	303-401	201-302	201-300	201-300	201-300	201-300	301-400	301-400
National Rank	UR	UR	141-168	119-140	118-140	115-139	91-112	90-111	90-110	86-109	86-108	105-125	103-125

UR: Unranked

Although ARWU does not provide the final weighted scores or exact rankings for all institutions, it does provide institutions' scores on each of the six indicators used to arrive at the final overall score. These indicators include including; i) the number of staff winning Nobel Prizes and Fields Medals; ii) the number of alumni winning Nobel Prizes and Fields Medals; iii) the number of highly cited researchers as determined by Thomson Reuters (HiSi); iv) the number of papers published in Nature and Science (N&S); v) the number of papers indexed in major science and social science citation indices (PUB), and;

vi) the per capita academic performance of an institution (PCP). For each of these six indicators, the highest scoring institution is assigned a score of 100, and other institutions are calculated as a percentage of the top score.

By tracing UCF's scores on each of these indicators over time, we gain a sense of UCF's performance relative to the highest ranking university (consistently Harvard) and which of the six indicators play a role in carrying UCF in ARWU's rankings. While the UCF has earned a score of 0 with respect to alumni and staff awards relative to Harvard, UCF's relative research output and its number of highly cited researchers have allowed the university to maintain its position in the ARWU rankings. In particular, the number of publications in Nature and Science has risen steadily since 2005, driving the rise of PCP indicator and likely the overall ranking of UCF.

Figure 6: UCF Relative Scores on ARWU Ranking Indicators

To complement their overall ranking, ARWU also developed rankings by subject for the top 200 universities using a methodology similar to that used to compute the overall

rank. As seen in the table above, UCF has frequently ranked among the top 200 universities in Engineering and Social Sciences fields. Engineering in particular is a strong subject area for UCF, as the school has ranked among the top 150 universities in the world four times since 2007.

Table 5: UCF Placement in Annual ARWU Global Rankings by Subject[71]

	2007	2008	2009	2010	2011	2012	2013	2014	2015
Natural Science & Mathematics	-	-	-	-	-	-	-	-	-
Engineering, Technology & Computer Science	77-106	-	-	76-100	-	101-150	101-150	-	-
Life & Agricultural Sciences	-	-	-	-	-	-	-	-	-
Clinical Medicine & Pharmacy	-	-	-	-	-	-	-	-	-
Social Sciences	-	-	-	-	-	151-200	-	-	151-200

Overall, the ARWU rankings indicate that UCF's performance has been steadily improving since 2003, placing it among the top 500 universities globally and top 200 nationally. UCF's performance in the sciences, particularly the number of scientific publications, seems to be driving its rankings, with a particular strength in engineering and social sciences, while historical prestige of alumni and students has held it back.

[71] Given that ARWU only published the ranks of the top 200 universities, the absence of a rank in the table above indicates that UCF was not among the top 200 universities in that field.

Leiden Rankings

In addition to ARWU, the Leiden Rankings were analyzed in order to gain a better understanding of UCF's strengths by discipline. The Leiden rankings are an annual global university ranking based on the volume and citation impact of publications found in the Web of Science database. Rankings are published for the 750 universities with the highest publication output. Leiden publishes two sets of rankings. The size dependent ranking ranks universities on the *total number* of scientific publications, as well as the number of publications which fall into the top 50%, 10% and 1% of their field (based on citations). In an attempt to correct for institutional size and better reflect the quality of a university's publications, size independent rankings are provided based on the *proportion* of a university's publications that fall into the top 50%, 10% and 1% of their field. UCF's 2015 rankings are provided in Table 6 for both sets of rankings.

Table 6: UCF's Overall and Field Specific Global Rank by Leiden

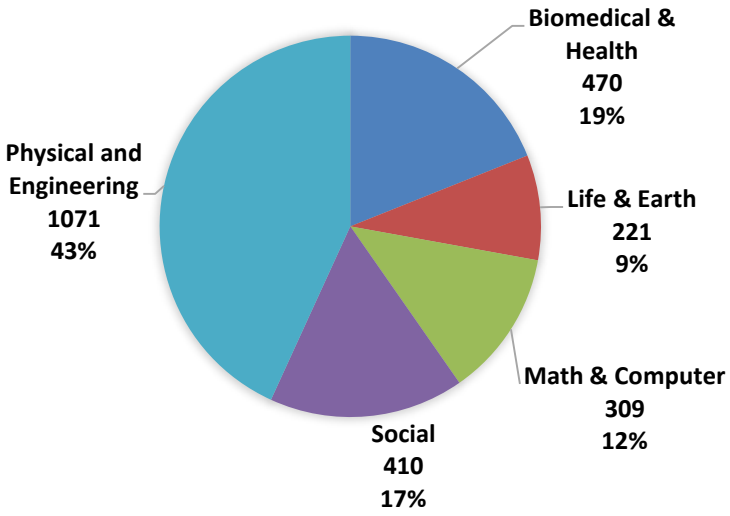
Field	Size Dependent Rank				Size Independent Rank		
	Total	Top 50%	Top 10%	Top 1%	Top 50%	Top 10%	Top 1%
All Sciences	382	356	331	333	305	249	267
Biomedical & Health Sciences	526	497	485	573	345	396	571
Life & Earth Sciences	493	490	418	330	411	265	158
Mathematics & Computer Science	258	281	279	435	426	333	476
Physical Sciences & Engineering	249	229	191	152	157	126	112
Social Sciences & Humanities	188	302	216	302	241	307	364

In 2015 UCF ranked 331st with respect to the total number of scientific publications which were considered among the top 10% in their fields. When publication volume is controlled for, UCF's overall rises in rank to 249th, indicating the high quality of its publications. Although UCF does not display a particular strength in the biomedical

sciences and earth sciences in terms of the number of highly cited publications, its rank in both fields rises by over 100 spots in the size independent ranking system. Of particular note is UCF's performance in the physical and engineering sciences, where it ranks among the top 150-200 universities in both ranking sets.

UCF's strength in physical and engineering sciences relative to other universities is underscored by its internal focus on research in this area. As seen in chart X, UCF publishes more papers in the physical and engineering sciences than any other field, with 43% of the institution's total publications categorized in these disciplines between 2010 and 2013.

Figure 7: UCF Publication Output by Science Field (2010-2013)



Although engineering remained the largest research area for UCF throughout all four Leiden rankings, the fastest growing research area within the university has been in

biomedicine and health. In between 2006 and 2009, biomedical publications accounted for 15.2% of UCF publications; within three years, this had risen to nearly 19% while the relative proportion of publications in engineering and math fell slightly. Given that the Burnett College of Biomedical Sciences was not established until 2004 and the College of Medicine (which subsumed the Burnett College) was not established until 2006, this rise in biomedical research output may directly reflect the growing strength and focus of the new medical school. Size independent rankings, however, show that the proportion of UCF biomedical publications belonging to the top 10% of their field has remained relatively constant, at 8-9%.

MUP Rankings

Between 2001 and 2013 the Center for Measuring University Performance (MUP) produced an annual ranking of the top U.S. research universities based on nine measures selected to reflect their research, resources, faculty performance, and education quality. In 2011, UCF ranked 107th in the country among all major U.S. research universities.[72] Unfortunately, UCF's overall ranking by MUP cannot be traced over time as a comparable overall ranking was only provided for the top 50 institutions in other reports. However, exhaustive sub-rankings were provided for each of the indicators used to arrive at the overall ranking, providing further insight into UCF's strengths and weaknesses.

Because federal research funding is peer reviewed and the competition is conducted on an open nationwide basis, it is widely considered a good indicator of the quality of university faculty and research. In 2000 UCF ranked 188th among all U.S. universities with respect to federal research funding and 131st amongst public universities; by 2011 these

[72] For 2011, MUP report defined "major research universities" as all universities with a federal research expenditure of over $40 million; 137 institutions met this criterion in 2011.

ranks had risen to 137th and 97th respectively, indicating a rise in both the quality and the quantity of research output.

Similar to the ARWU rankings, UCF does not perform well on measures of faculty performance and prestige. MUP counts the number of National Academy members and the number of prestigious awards received by faculty in order to assess an institution's ability to recruit and retain competitive faculty members. In 2012, only one UCF professor was a member of the National Academy; in contrast, the public institution with the largest number of National Academy presence had 230 members. Similarly, UCF faculty earned seven prestigious faculty awards compared to 45 at the public university ranking highest on this indicator.

In order to assess the quality of undergraduate programs, MUP considers the total number of National Merit Scholars attending an institution as well as the average entering SAT score (reading and math) of freshman. In 2012, UCF attracted 68 National Merit scholars, ranking 32nd among all universities and 13th among all public institutions. With a median SAT score in 2011 of 1185, UCF ranked 220th among all U.S. universities and 57th among public universities, rising 94 and 18 spots respectively since 2003 when the median score was 45 points lower. A look at UCF's website shows that the quality of the undergraduate class has continued to improve, with average SAT scores rising 13 points between 2013 and 2015 and the average high school GPA rising from 3.89 to 4.0.[73,74] An exploratory ranking by MUP in their 2013 report underscores the strength of UCF educational programs: in a ranking based solely on educational indicators (doctorates awarded and median SAT scores), UCF rose from 107th to 82nd in an overall ranking of all

[73] "Freshman Applicants." University of, n.d. Web. 30 Mar. 2016. <https://admissions.ucf.edu/apply/freshman>.
[74] Postal, Leslie. "UCF Enrollment Tops 60,100." Orlando Sentinel, 4 Sept. 2013. Web. 30 Mar. 2016. <http://www.orlandosentinel.com/features/education/school-zone/os-ucf-enrollment-record-post.html>.

U.S. universities (both public and private). In addition to increasing access to skilled labor in the Orlando area, this rising undergraduate profile may be a significant asset in recruiting and retaining highly productive faculty and staff.

A. U.S. News Rankings

U.S. News and World Report education rankings ranked UCF 168th overall among national universities and 91st among public universities in 2016. UCF was also recognized as the 13th "Most Innovative School" in the nation based on college officials' opinions of which universities were making the most innovative improvements in terms of curriculum, faculty, students, campus life, technology and facilities. UCF's College of Medicine, however, has remained unranked by U.S. News' assessment of the best medical schools, implying that it was in the bottom 25% in both research and primary care.

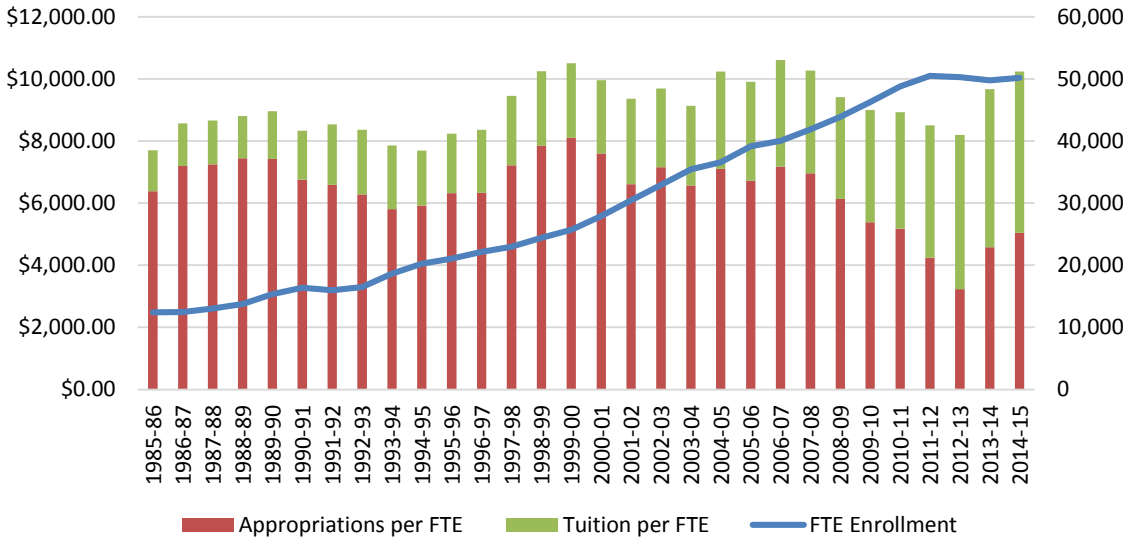
UCF FUNDING

The above analysis of UCF rankings demonstrates a strong university partner poised to provide the Orlando biotech community with opportunities for collaborative research and access to a pool of highly skilled students. However, decreases in funding following the 2008 economic crisis have placed UCF in a very different financial position than would have been predicted at the time Sanford Burnham decided to join Lake Nona. Efforts to increase tuition and total enrollment numbers have not made up for cutbacks in state funding, resulting in low levels of funding per FTE at UCF. Assuming constant costs per FTE, these falling funding levels would have limited resources remaining for research efforts and thus the development of UCF's biomedical research capacity.

State Funding

Between 2007 and 2012 total education and general (E&G) state appropriations for the State University System of Florida (SUS) fell by more than 38%, making it the state with the second largest funding decrease in the nation during those years.[75] UCF was not immune to this trend; as shown in Figure 8, educational appropriations per FTE at UCF fell from $7,174 in 2006 to a low of $3,234 in 2012 – a 55% decrease.

Figure 8: UCF FTE Enrollment & Total Revenue per FTW by Funding Source (constant 2009$)

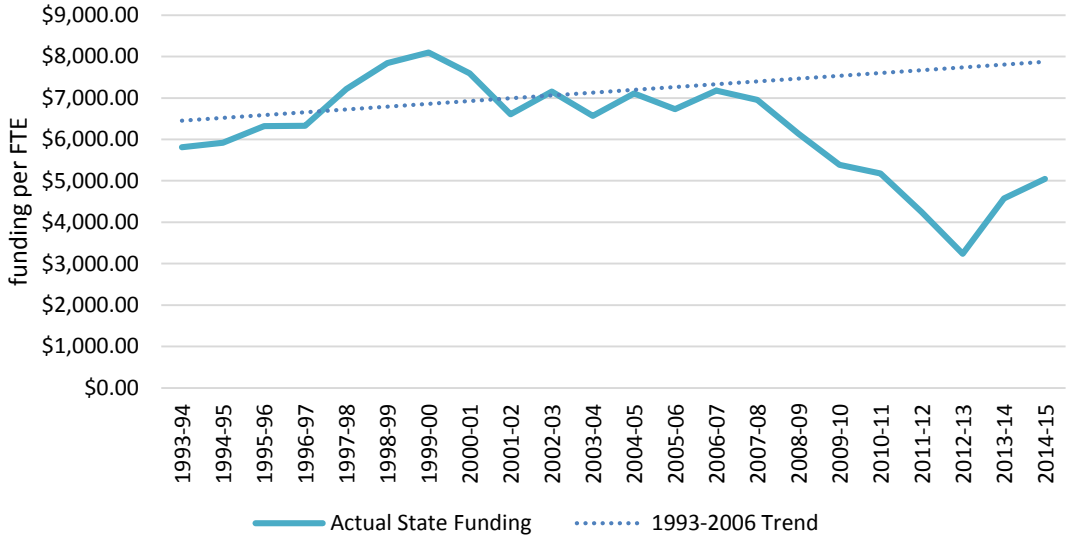


Prior to the financial crisis, Florida universities had received consistent financial support from the state since the early 1990s (though funding growth did stall in the early 2000s, in part due to the brief 2001 recession). The trend line in Figure 9 demonstrates what total state funding per FTE would have been at UCF had it continued to rise at the

[75] Malcolm, Hadley, and Sean McMinn. "Sagging State Funding Jacks up College Tuition." *USA Today*. 3 Sept. 2013. Web. <http://www.usatoday.com/story/money/personalfinance/2013/09/02/state-funding-declines-raise-tuition/2707837/>.

1993-2006 trend rate (a trend Sanford Burnham would likely have anticipated when it made the decision in 2005 to establish itself in Orlando). In FY 2012, state funding per UCF FTE had fallen to $3,234 – nearly 60% below a funding level of $7,738 per FTE which could have been estimated from 1993-2006 funding trends. Although state funding for universities began to rise in 2013 as the state economy recovered from the recession, state funding per FTE at UCF in 2014 remained 36% below trend.

Figure 9: Predicted vs. Actual UCF State Funding per FTW (constant 2009 $)



Tuition Revenue

Universities throughout Florida, including UCF, resorted to a number of strategies in order to compensate for falling state funding, including raising tuition within limits set by the Florida legislature. Under Governor Charlie Crist, a number of changes in Florida law allowed Florida universities to raise tuition rates during the recession more

dramatically than ever before.[76] Prior to 2009, the legislature set undergraduate tuition rates, and the Board of Governors set graduate and out-of-state rates. Beginning in 2009, the legislature allowed the Board of Governors to raise undergraduate tuition rates (at a rate called the tuition differential) beyond the base rate increase approved by the legislature, as long as the sum of the two increases did not raise tuition by more than 15%. In its requests to the Board of Governors, UCF attempted to maximize total tuition increases by requesting a tuition differential that would raise tuition by the cap of 15% when combined with the legislative base increase.[77] Indeed, between 2009 and 2011, the sum of the base increase and the tuition differential for the state of Florida reached the cap of 15%.

As seen in the graph below, real tuition revenues per FTE at UCF increased rapidly beginning in FY2009 as UCF took advantage of its ability to raise tuition. In FY 2012, real tuition revenue per FTE was 51% higher than FY 2008 compared to a 13% increase which would have been predicted had tuition revenue per FTE continued to rise at the 1993-2006 trend.

Governor Rick Scott (who entered office in 2011) is largely opposed to raising tuition rates and has used his influence with the legislature and Board of Governors to limit increases since 2012. In 2013, tuition increases were automatically capped at the rate of inflation after Scott vetoed a legislative increase and influenced the Board of Governors to set a tuition differential of zero percent. In 2014, the tuition differential process was scrapped entirely and the provision for a minimum automatic tuition increase set at the rate of inflation was eliminated. These limitations on tuition growth for UCF are reflected in

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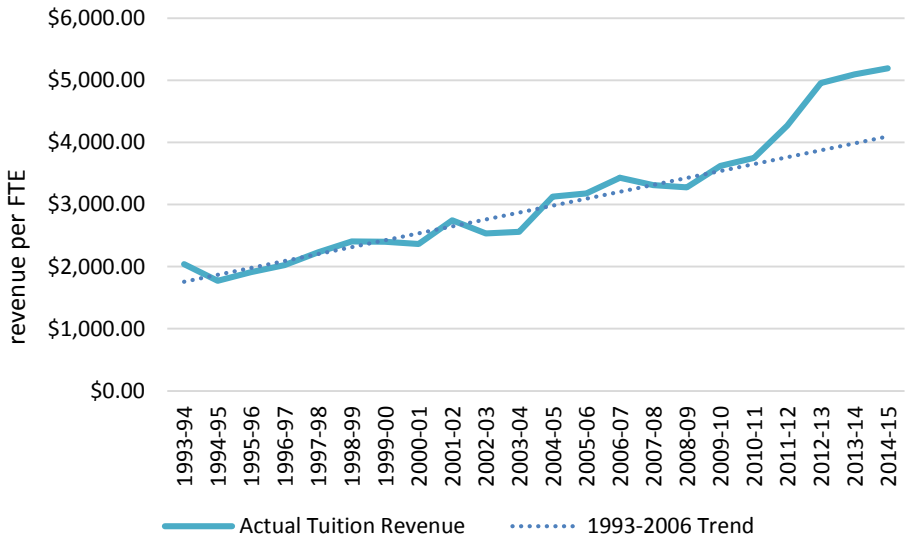
[76] Gillin, Joshua. "Rick Scott Says Charlie Crist Let Tuition Increase 5% Ever Year." Politifact Flrida, 4 June 2014. Web. 20 Mar. 2016. <http://www.politifact.com/florida/statements/2014/jun/04/rick-scott/charlie-crist-allowed-college-tuition-increase-15-/>.

[77] *Tuition Differential Fee Reports*, State University System of Florida

Figure 10, as tuition revenue per FTE returns to growing at previous trend rates. However, during Charlie Crist's administration, UCF tuition revenue per FTE remained 27% higher than could have been predicted otherwise.

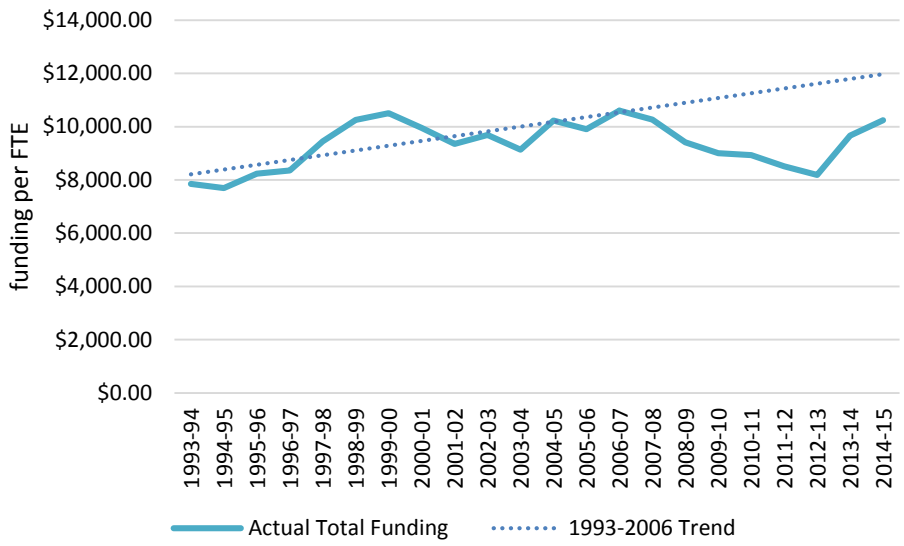
Figure 10: Predicted vs. Actual UCF Tuition per FTE (constant 2009 $)



Tuition hikes by Florida universities, however, could not compensate for plunging state funding. This was due to the fact that Florida tuition rates were extremely low to begin with. In 2007, immediately before the crisis, the average published tuition and fees of public four-year institutions in Florida were the lowest in the nation.[78] As a consequence, although tuition grew at a rapid rate, the *absolute* increase in tuition revenues was small and total funding per FTE remained low (see Figure 11 below). Indeed, total revenue per FTE at UCF fell each year between 2006 and 2012 despite annual tuition increases.

[78] *Trends in College Pricing 2015*. Rep. The College Board. Web. 18 Apr. 2016.

Figure 11: Predicted vs. Actual UCF Total Funding per FTW (constant 2009 $)



Although total funding per FTE began to rebound in 2013 as the national economy and state funding has recovered, total funding per FTE at UCF remained 14.5% lower in 2014 than would have been predicted had it risen at the 1993-2006 trend rate.

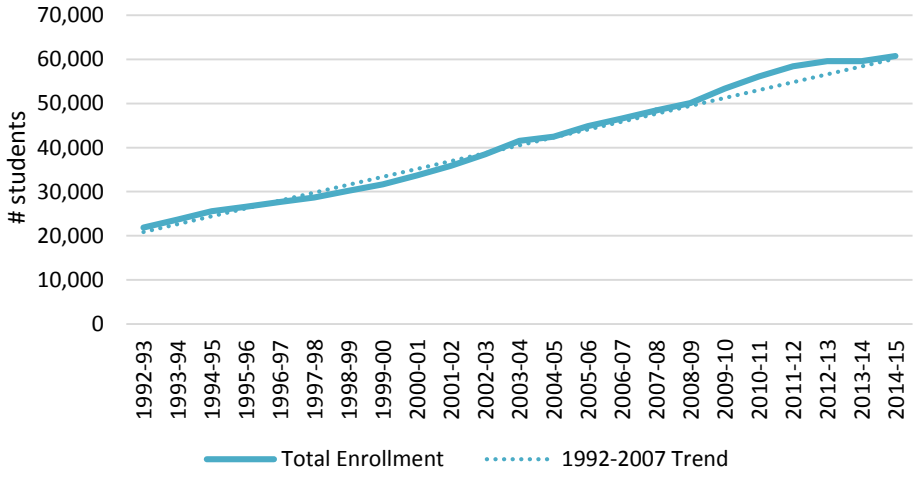
Stalling FTE Enrollment and Tuition Revenue

Prior to the economic crisis, UCF had long been pursuing a strategy of rapidly increasing enrollment rates. According to the National Center for Education Statistics' Integrated Postsecondary Education Data System, between 1993 and 2008 total student enrollment increased by 112%, from 23,692 to 50,121, making UCF the second largest four year university in the U.S. (after Arizona State University) and the largest in Florida. John Hitt, UCF's president since 1992, has overseen this explosive growth and has not

shown an interest placing limits on enrollment, asserting in a recent interview that it's possible for a university to be both "big and good".[79]

In response to falling funding levels during the economic crisis, enrollment rose at universities as the opportunity cost of going to school fell relative to work opportunities. Indeed, many universities actually made a concerted effort to increase enrollment in an attempt to attract proportionally more state funding. These two trends boosted UCF's already high enrollment rates. As seen in the graph below, enrollment between 2009 and 2012 rose more rapidly than would have been anticipated. In 2011, enrollment was 6.6% higher than would have been predicted by 1992-2007 trends. Enrollment rates, however, appear to have slowed in 2013, returning to total enrollment prior trend levels as the economy and state funding for universities began to rebound.

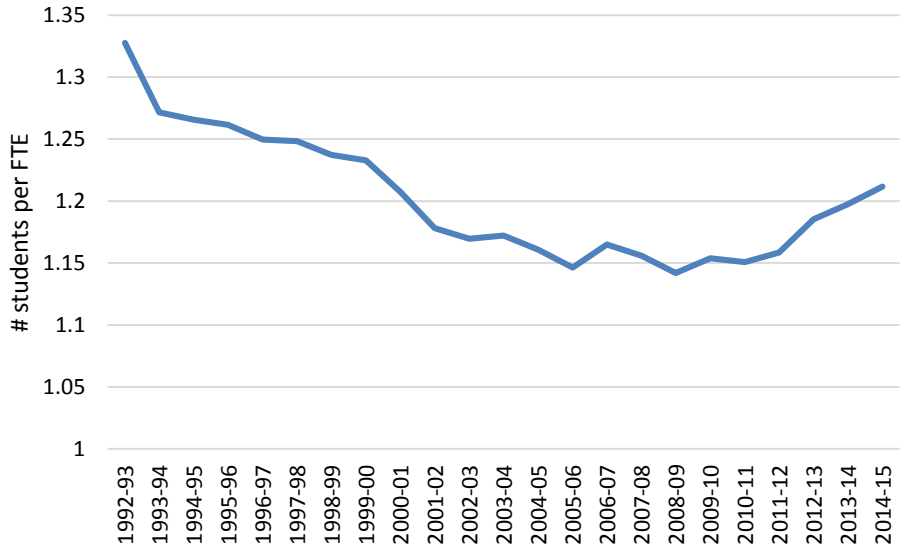
Figure 12: UCF Total Enrollment



[79] Kealing, Bob. "UCF Discussion Covers Vision for Downtown Campus." WESH Orlando, 30 Sept. 2015. Web. 1 Mar. 2016. <http://www.wesh.com/news/ucf-discussion-covers-vision-for-downtown-campus/35581724>.

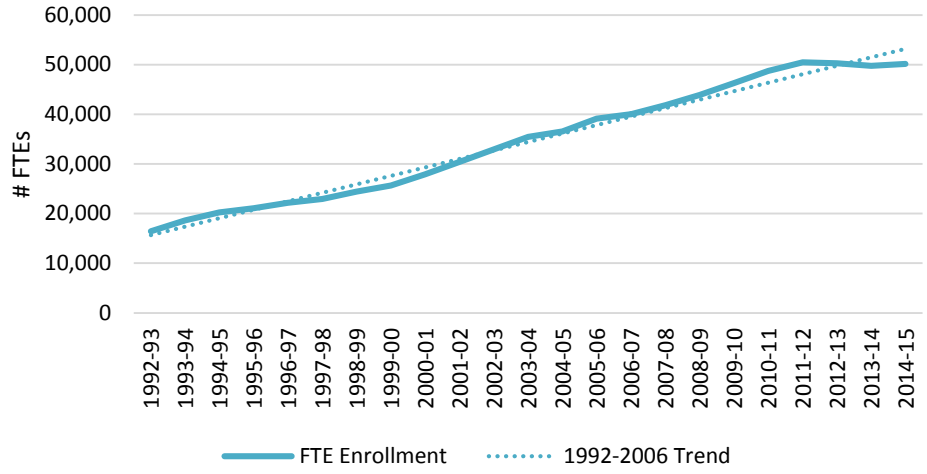
It is important to note however, that state funding for universities correlates with full time equivalents (FTEs), not necessarily total enrollment. An analysis of UCF FTE enrollment during the recession shows that although FTE enrollment also rose faster than would have been anticipated based on 1992-2007 trends, it rose at a slower rate than total enrollment, implying that UCF was enrolling part-time students at a faster rate than full-time students. This is confirmed in the following graph presenting the total number of students enrolled per FTE at UCF between 1992 and 2014. This ratio began an upward trend beginning in 2008 after falling steadily for over fifteen years.

Figure 13: UCF Students per FTE



UCF has continued to enroll part-time students at a faster rate than full-time students, even as increases in total enrollment have fallen in the last two years. As a result, there has essentially been zero growth in total FTE enrollment between 2011 and 2014, as seen in the graph below.

Figure 14: UCF FTE Enrollment



Thus, although UCF enrollment rose during the recession, FTE enrollment did not rise as quickly, likely limiting its ability to attract state funding and raise additional funding throughout during the Great Recession.

Future Funding Prospects

UCF funding per FTE began falling immediately after UCF established itself at Lake Nona. Assuming costs per FTE remained constant, this drop would have limited UCF's ability to develop its biomedical research capacity and thus to partner with and accelerate the development of the Lake Nona research community. The fall in funding levels was most directly attributable to the large decrease in state appropriations for the Florida university system. A combination of increased tuition and increased enrollment was unable to offset this funding fall for reasons discussed above.

Fortunately, state funding has risen rapidly as the Florida economy has recovered from the Great Recession. Between 2012 and 2014 alone, total real state funding increased

by 55%. As state funding continues to recover and as UCF enrollment falls back to pre-recession growth rates, funding per FTE will continue to rise, providing resources for research, including collaboration with Sanford Burnham.

Chapter 8: Conclusion

The policy-driven industrial cluster at Lake Nona was a result of the aggressive efforts of the state of Florida under Governor Jeb Bush and the vision of the Tavistock Group. The cluster, however, has failed to yield the anticipated economic impact for Orlando as heralded by early supporters and related studies. This paper sought to understand the reasons for the muted success of the planned cluster by conducting comparative qualitative case studies with other clusters and analyzing trends in factors considered key to the success of any biotechnology cluster, including the availability of basic and translational funding (i.e. NIH funding and venture capital) and the strength and contributions of the University of Central Florida – considered a key anchor institution for the cluster's development. Findings reveal:

- **An eight-year development timeline was optimistic given the path-dependent development of leading U.S. biotechnology clusters.** Although there is no one recipe for cluster development based on qualitative case studies conducted, it is evident that even with local support, key clusters in the U.S. took decades – if not centuries – to develop. New clusters such as Lake Nona must struggle not only to overcome such a traditional timeline, but compete with these established clusters for resources such as venture capital and skilled labor. However, if other challenges listed below are overcome by Lake Nona, advancements in areas such as transportation and communication may allow the region to develop more quickly than its predecessors.
- **Venture capital has been harder to access than expected at Lake Nona's founding due to the Great Recession.** Following the great recession, venture

capital resources fell across the board. As the economy has recovered and funding for the biotechnology industry has rebounded, venture capitalists have maintained their risk aversion and concentrated their investments on older, more established firms. This would inhibit the development of translational research, spinoffs, and a thriving industrial cluster at new biotechnology centers such as Lake Nona. Chapter 4 made a few suggestions as to how policymakers at the federal level could take steps to encourage venture capital flows to new establishments. However, barring \ dramatic shifts in the risk-tolerance of the venture capital industry, aspiring clusters like Lake Nona will continue to face a challenge in attracting adequate venture capital in order to fuel the commercialization of biomedical discoveries.

- **NIH funding fell dramatically during the Great Recession, inhibiting basic research efforts at Lake Nona which were considered critical to the cluster's success.** Lake Nona visionaries could not have planned for the Great Recession or the dramatic fall in public research funding that accompanied it. NIH funding levels in 2015 were nearly 20% below what developers would have imagined had funding continued to increase at historical levels. Anchor institutions focused on basic research such as UCF and key partners such as Sanford Burnham would have been unable to contribute to the cluster's development as anticipated. However, Congress has displayed an interest in reversing this trend in in recent legislation. Such a renewed focus on the life sciences is likely to continue given demographic shifts and advancements in technology (as mentioned in Chapter 5) and possibly allow the Lake Nona cluster to regain development momentum.
- **The College of Medicine – considered the anchor institution and central to Lake Nona's development – has proved to be a weak partner.** The UCF College of Medicine has failed to provide the human capital or serve as the funding magnet

anticipated. Despite lofty goals, the less than stellar reputation of the college is unlikely to change given this poor start and strong competition from other preeminent colleges. A weak college of medicine will continue to deter future members from joining the cluster, weaken networking effects and discourage partners who located to the area based on opportunities for future collaboration with the college.

- **In light of the weak academic and research support from the College of Medicine, the University of Central Florida more broadly has served as a supportive research partner, though UCF itself has been weakened by the recent recession and could not have compensated for the weak College of Medicine.** Although UCF boasts strengths in academic areas which are increasingly complementary to the biosciences – such as engineering and computer sciences – the school has witnessed a fall in enrollment and funding which would have weakened its ability to compensate for the weakness of the new College of Medicine. Although UCF is likely to regain strength as the national economy pulls away from the impact of the recent economic crisis, it is unlikely to ever fill the gap presented by the weak College of Medicine.

In sum, projections for the rapid development and success of Lake Nona were optimistic to begin with. The Great Recession posed challenges to partners and funding that further slowed the development of the cluster. Although basic research funding is likely to rebound in the future, key challenges such as access to venture capital and the strength of key partners are unlikely to be solved anytime soon. In light of such discoveries, Lake Nona stakeholders should remove pressure for immediate performance and instead turn their focus towards a longer term vision for success.

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