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The CvilleBioHub Region: A Report on the Local Biotechnology Industry, Metrics and Economic Impact

MARCH 2020

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This report was developed by CvilleBioHub and the Weldon Cooper Center for Public Service at the University of Virginia. The report was supported in part by an Enhanced Capacity Building Grant from GO Virginia, with additional support from the Charlottesville Economic Development Authority, Randolph Square Analytics, and sponsors of the CvilleBioHub.

ABOUT CVILLEBIOHUB

CvilleBioHub is a non-profit organization founded in 2016 to support the biotechnology community in and around Central Virginia, Charlottesville/ Albemarle and surrounding counties (the “CvilleBioHub Region” or “CBR”). Today, the CvilleBioHub Region is home to more than 60 biotech companies and non-profit organizations working to improve human health through drug development, medical device innovation, clinical research, agriculture/ nutrition, diagnostics, software, tools and instrumentation. The region hosts a high density of biotechnology firms in the Commonwealth of Virginia, many of which emerged from the University of Virginia Schools of Medicine, Engineering and Applied Science and the Darden School of Business.

As its mission, CvilleBioHub serves to strengthen the Greater Charlottesville biotechnology industry through **engagement, resourcing** and **advocacy**.

Through CvilleBioHub’s 2019 Strategic Plan, the organization will drive growth of the industry from 2020-2030. CvilleBioHub is working with local, regional, and state economic development agencies to implement the strategic plan and to generate a vibrant and expansive biotechnology cluster, which will help bolster a technology-based economy for the future. The CvilleBioHub Region will be a recognized cluster at the forefront of developing new innovations in healthcare that will serve the public and improve quality of life.

ABOUT WELDON COOPER CENTER FOR PUBLIC SERVICE

The mission of the Weldon Cooper Center for Public Service is to strengthen and preserve effective government in Virginia by leveraging the research, expertise, and resources of the University of Virginia to inform public policy, develop public leaders, and deliver strategic and technical assistance.

Introduction

MAJOR OBJECTIVES OF THE INDUSTRY REPORT:

1. To analyze the current status and future outlook of the biotechnology industry in the CvilleBioHub Region.
2. To benchmark the activities and impact of CvilleBioHub.

CvilleBioHub was founded in 2016 to support the growth and development of the biotechnology and life sciences industry in the CvilleBioHub Region comprising the cities of Charlottesville, Staunton, and Waynesboro; and Counties of Albemarle, Augusta, Culpeper, Fauquier, Fluvanna, Greene, Louisa, Madison, Nelson, Orange, and Rappahannock.

In 2019, CvilleBioHub received an Enhanced Capacity Building Grant from GO Virginia, a new statewide economic development initiative, to develop an in-depth analysis of the impact of the biotechnology industry in the region. Recent reports identified “Biotechnology and Biomedicine” as one of five target areas of GO Virginia Region 9 economic development and growth (Camoin Associates, 2017; TEconomy Partners, 2018). The biotechnology industry in the CBR is a diverse collection of innovative and entrepreneurial companies and other organizations developing technologies that impact human health through drug development, medical device innovation, agriculture/nutrition, clinical research, diagnostics, software, tools and instrumentation. The majority of these companies are spinouts with technology developed by faculty and researchers at the University of Virginia; thus, it is a principal driver of new company creation in the industry.

CvilleBioHub has partnered with the Weldon Cooper Center for Public Service at the University of Virginia to provide the first report of the impact of the biotechnology industry in the region in the last decade. Industry metrics were collected and analyzed in 2019 to establish:

- > **Breakdown of companies by subsector and highlights of activity within each subsector**
- > **Economic impact in terms of employment using IMPLAN and other analytical tools**
- > **Research and Development productivity via patents and grant awards**
- > **Activity of CvilleBioHub as a regionally-focused organization supporting the industry across all stages**
- > **Capital investments from local angel funds, venture capital and other sources**
- > **Occupied infrastructure in the regional industry**

Biotechnology Industry in the CvilleBioHub Region

The CvilleBioHub Region has a robust and dynamic biotechnology community representing several sectors of the industry.

A goal in creating the organization was to highlight and spread awareness surrounding the depth of biotechnology companies and organizations in the region and of the state-of-the-art technologies being developed in medicine, science, healthcare and agriculture. The first step was to collect metrics on the number of companies in the region, the number of employees and the amount of real estate occupied. These initial data were presented at CvilleBioHub-hosted meetings and in discussion with local economic development groups in early 2017. Together, these efforts focused on the scope and scale of the regional biotechnology industry.

A total of **67 companies, foundations and educational organizations** were included in this analysis, classified into the following subsectors: Devices & Instrumentation, Therapeutics, Health Tech & Software, Agriculture & Food Technology, Consulting, Biomanufacturing, Foundations & Non-Profit, and Clinical Research (**Table 1**).

TABLE 1. BREAKDOWN OF BIOTECHNOLOGY COMPANIES/ ORGANIZATIONS IN CBR BY SUBSECTOR.

INDUSTRY SUBSECTOR	# OF COMPANIES	# OF EMPLOYEES	NON-DILUTIVE FUNDING \$M	EQUITY FUNDING \$M	OCCUPIED FOOTPRINT sf
Devices & Instrumentation	25 (37%)	1,094	19.3	62.1	503,350
Therapeutics	12 (18%)	79	29.1	190.3	31,600
Health Tech & Software	9 (13%)	90	1.2	9.2	16,300
Agriculture & Food Tech	7 (10%)	78	1.8	14.5	70,350
Consulting	5 (7%)	55	N/A	N/A	10,000
Biomanufacturing	4 (6%)	120	2.1	N/A	119,000
Foundations & Non-profit	3 (4%)	81	0.7	N/A	18,100
Clinical Research	2 (3%)	353	N/A	N/A	67,000
TOTAL	67	1,950	54.2	276.1	835,700

Subsectors

The following section outlines the eight subsectors of CvilleBioHub, with summaries, updates, and company profiles from each.

MEDICAL DEVICES & INSTRUMENTATION

The Medical Devices and Instrumentation subsector is the cornerstone of the CvilleBioHub Region, due in part to the highly ranked University of Virginia School of Engineering and Applied Science, Biomedical Engineering Department and the UVA School of Medicine. The subsector comprises 25 companies, 1,094 employees and is thus the largest subsector CBR (37% of companies). Of note, this sector includes:

HUB HIGHLIGHT

The Medical Devices & Instrumentation Subsector is the largest in the CBR, accounting for 37% of companies. Most are privately held, self-funded, and are significant drivers of economic development.



Cadence, a supplier and contract manufacturer of advanced products, technologies and services to medical device, life science and other industries located in Staunton with 500 employees and 250,000 square feet of space. Due to their connections with Charlottesville, they are considered as part of the companies in the CBR and make up a quarter of employees in the entire region.



Microaire Surgical Instruments, with 152 employees is the second largest medical device company by employee count in the CBR. The company moved from California to Charlottesville in 1995 and has since become a top manufacturer of surgical instruments that include applications for endoscopy and facial and body contouring.



Lighthouse Instruments delivers laser-based headspace analyzers for monitoring of sterile pharmaceutical drug manufacturing processes.



1,094

employees in the Medical Device and Instrumentation subsector



LumaCyte applies unique laser force cytology for single cell analysis for research in vaccines and cancer therapeutics among other applications.



BrightSpec manufactures molecular rotational spectrometers for drug analysis.



Rivanna Medical is commercializing Accuro, an epidural guidance device with FDA 510k approval that improves the success of epidural and spinal anesthesia.



Caretaker Medical has developed a low-cost, wireless, vital signs monitor and blood-loss detection device, “CareTaker4”, that is FDA cleared, and can monitor patient vital signs from anywhere in the world.



Contraline is developing a long-acting, reversible male contraceptive (“LARC”) using injectable hydrogel technology.

Companies such as **Cerillo**, **LumaCyte**, **BrightSpec**, and **MicroGEM** manufacture novel and sophisticated instruments for research and biomanufacturing. These companies manufacture specialized instruments with typical market value of \$100K - \$1M. Several medical device companies are developing innovative products for patient care.

This sector also includes prominent start-ups such as **Soundpipe Therapeutics**, **Direct Spinal Therapeutics**, **BrachyFoam** and **MIST** that will become the next wave of commercial device and instrumentation companies in the region. Most of the companies in this subsector are privately held and several are self-funded. The most established companies have strong commercial revenues, dedicated manufacturing facilities and are responsible for export sales in the millions of dollars. These companies are primed for growth and job creation, and are significant drivers of economic development in the CBR.

ACQUISITIONS FUEL CYCLE OF OPPORTUNITY AND GROWTH

Drug development is an expensive, risky and time-consuming endeavor with incredible rewards for success.

Therapeutics companies in the CBR require the highest amount of funding per company, on average \$15.9M, where in total companies have received at least \$190M of investment dollars over the past 10 years.

This compares to the medical device and instrumentation subsector, which has raised on average \$2.5M per company, as reported.

Once a drug company is founded around a unique scientific insight or medical technology, it can take years and significant investment to conduct the laboratory and animal research necessary to demonstrate potential. This can trigger an even greater need for financial resources to enter into clinical trials to confirm drug safety and efficacy in humans. The value of companies increases as they achieve success along the clinical research path, making them ripe for acquisition.

Broadly, drug manufacturers spent a record \$342 billion on M&A in 2019.

THERAPEUTICS

The Therapeutics subsector comprises private sector companies that have often spun out from UVA to commercialize biomedical research and develop novel drug programs. Many companies involve collaborations between academic biomedical scientists, entrepreneurs, clinicians, and investors to carry out discovery and pre-clinical research programs which, if successful, move on to Phase I-III human clinical trials. Median costs of clinical trials are significant, varying between \$19M and \$157M, depending on complexity of the trial and treatment indication (Johns Hopkins Bloomberg School of Public Health, 2018). As the process is very capital intensive, companies often form partnerships or are acquired by larger biotech and pharmaceutical companies to accelerate drug approvals and launch. This sector comprises 12 companies and 71 employees, an average of 6 employees per company, emphasizing much of the knowledge work required by these small teams.



Diffusion Pharmaceuticals (NASDAQ: DFFN) has been a Charlottesville-based company since 2004 developing drugs to treat tissue hypoxia. In December 2019, the company announced closing of \$3.5M offering to continue to develop its lead compound candidate TSC, which includes further clinical trial work (Diffusion Pharmaceuticals, 2019). TSC is currently in Phase II and Phase III clinical trials.



HemoShear Therapeutics is discovering new drug targets to treat metabolic disorders for patients with significant unmet therapeutic needs. HemoShear's proprietary REVEAL-Tx™ platform combines biological and computational models of human disease to accelerate discovery of novel targets and successful new drug treatments. HemoShear employs 25 employees and occupies 16,000 square feet of customized laboratory space.



ZielBio is a newly emerged spinout from the University of Virginia that completed a \$26.1M Series A fundraising round in 2019 to support development of a monoclonal antibody for targeted oncology therapies.

Other companies in the Therapeutics subsector include **Adial Pharmaceuticals**, **AMPEL BioSolutions** and **Tear Solutions**.

HUB HIGHLIGHT

The convergence of the tech industry with biotech and health care is demonstrated in the Hub by companies like TypeZero, Medical Automation Systems and ArcheMedX. New companies in this space in the CBR are emerging and growing.

HEALTH TECHNOLOGY AND SOFTWARE

The Health Technology and Software (“HealthTech” or “Digital Health”) subsector of the biotechnology industry is the newest and fastest-growing in the nation, as software IT converges with problem solving in healthcare and biotech. In 2018, \$8.1 billion was invested nationally in companies leveraging data and software to improve human health, a 42% increase in just one year (Ross, 2019). The FDA is determining how to regulate this emerging industry and in 2019 the Center for Devices and Radiological Health (CDRH) established a new Digital Health Innovation Plan (FDA, 2020). The CBR is also experiencing significant growth in this subsector.



Locus Health is one such established company with 45 employees and a software platform that connects care teams to patients, bridging the gap between hospital and home.



Medical Predictive Science Corporation develops computational diagnostic and bioinformatic technologies for the healthcare industry.

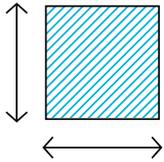


ArcheMedX has a software platform that applies behavior science to improve learning for improving clinical trial operations and medical education.

Emerging companies in this subsector include **MIST**, **NeuroView**, **ScanOptix**, and **SpringBok**.

The entrepreneurial efforts in HealthTech have potential to benefit from the growing software industry in the region.

Timelines to exits in the software industry are faster than the capital- and time-intensive biotech and pharmaceutical industries. Example of exits in the past decade in HealthTech in the CBR include **Medical Automation Systems** (2011, by Alere, and then in 2017 by Abbott) and **TypeZero** (2018, acquired by Dexcom). Both Dexcom and Abbott have retained a presence in the region with satellite offices and staff from the acquired companies.



119K

sf of space in the Biomanufacturing sector alone, identified as an opportunity for growth in the CBR

AGRICULTURE AND FOOD TECHNOLOGY

The Agriculture and Food Technology subsector (AgTech) is expanding in the CBR with several new companies founded in the last 5 years. **Bonumose Biochem** moved its operations to Charlottesville from Blacksburg, Virginia to develop the processing and scaling of tagatose, a safe and healthy sugar alternative for the food industry and consumer markets. **AgroSpheres** has developed a novel biological platform as a safe alternative to pesticides in agriculture. In 2019, they successfully recruited Doug Eisner, an experienced AgTech executive, as CEO from North Carolina and raised a \$4M series A round lead by Ospraie Ag Science. Other emerging entities in this subsector includes **Lytos Tech**, **Fiacre**, **Seraphic Group**, and **Babylon Microfarms**.

CONSULTING

Consultants in the biotechnology industry are often critical for expanding pathways and capabilities in very specific areas of expertise, such as regulatory compliance, manufacturing and toxicology. In the CBR, companies including **Toxicology Regulatory Services (TRS)**, **Signature Science** and **NDA Partners** support the local and national industry through a wide range of services from regulatory support and government contract work.

BIOMANUFACTURING

The Biomanufacturing subsector in the biotech industry covers a broad spectrum of technologies and applications. The four main identified companies (Indoor Biotechnologies, Afton Scientific, BIO-CAT, PurSolutions) in the region are no exception.



Indoor Biotechnologies is an allergen manufacturing leader, operating for more than 20 years, and has three worldwide locations, where allergens and environmental test kits are manufactured locally and sold globally. They employ 25 researchers, scientists and staff and operate one of a few premier wet labs in the private sector within the region.



BIO-CAT is a 30-year-old Food Safety System Certified company located in Louisa County with 45 employees, operating in a 75,000 square foot facility that manufactures and offers enzymes for purchase, as well as services that include custom blending and R&D.

FOUNDATIONS AND NON-PROFITS

While biotechnology industry is traditionally comprised of for-profit companies, the CBR is proud host of two leading non-profits that enrich our community and advance science and technology around the world.

HUB HIGHLIGHT

The clinical research organizations operating in the CBR are a major asset to the industry around the globe as well as being major local employers.



The Focused Ultrasound Foundation is a global medical research, education and advocacy organization that is accelerating the development and adoption of this non-invasive therapeutic technology to improve lives.



The Center for Open Science is a non-profit organization focused on increasing openness and reproducibility to scientific research by offering free open-source software tools.

CLINICAL RESEARCH

The clinical trials subsector is growing at a rate of 6% and projected as a \$68.9B global market by 2026 (Grand View Research, 2019). Although this is the smallest subsector locally by number of companies, the two major clinical research organizations (CROs) in the CBR, **PRA Health Sciences** and **Atlantic Research Group**, employ some of the highest number of people at 253 and 100 employees, respectively. These organizations organize and implement labor intensive pre-clinical and clinical trials.



PRA Health Sciences was established in Charlottesville in 1976 as an anti-inflammatory drug study group and is today a global clinical research leader with more than 13,000 employees, headquartered in Raleigh, North Carolina (McKenzie, 2011).



The Atlantic Research Group in Charlottesville evolved as a spinout from PRA in 2004 and is currently focused on clinical trials in oncology, immunology, rare and neurodegenerative diseases.

Industry Metrics and Data

In developing this report, 67 organizations in the CBR were surveyed and reviewed in 2019. The Weldon Cooper Center used the standardized North American Industry Classification System (NAICS) code system and its IMPLAN (Impact analysis for PLANning) model to determine the industry impact factor.

ECONOMIC IMPACT RESULTS

The biotechnology industry is one of the largest and fastest growing industries in the CBR, accounting for 1,950 high paying technical, administrative, scientific, and managerial/executive jobs. These are clean, advanced manufacturing or tech career ladder jobs, with minimal environmental impact that come with attractive salaries and benefits. The average salary for biotech employees in the CBR in 2019 is \$93,450 or roughly double the GO Virginia Region 9 average salary of \$49,230.

Many employers in the region are export-based firms, deriving revenues chiefly from out-of-the region and out-of-state. These companies have benefited from the Virginia Economic Development Partnership VALET program and have export markets in Europe, China, Japan and other Asian countries. The companies serve as international ambassadors for the CBR and raise the profile and awareness of the CBR worldwide. These characteristics make the biotech industry cluster attractive from an economic development vantage point and result in high economic multipliers.

Table 2 shows results of economic impact as presented for four different economic measures: employment, output, value-added, and labor income. There are 1,950 employees working directly in the CBR and for every one direct employee there are 1.7 additional workers (total employed equals 5,261). The biotech industry in CBR has contributed to \$1.2B of production activity. Value-added is a subset of total industrial output. The total-value added (comparable to GDP measurement) by biotech industry in the CBR is \$601M. Overall, these values reflect high economic multipliers and are above average compared to other industries in the state.

**FOR EVERY ONE
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TABLE 2. CVILLEBIOHUB ECONOMIC IMPACTS ON STATE AND GO VIRGINIA REGION 9.

	DIRECT	INDIRECT	INDUCED	TOTAL	MULTIPLIER
VIRGINIA					
Employment	1,950	1,842	1,469	5,261	2.70
Output (\$M)	693.8	300.3	202.0	1,196.0	1.72
Value Added (\$M)	316.1	168.3	116.7	601.1	1.90
Labor Income (\$M)	177.4	109.4	62.8	349.6	1.97
GO VIRGINIA REGION					
Employment	1,450	1,336	970	3,756	2.59
Output (\$M)	543.9	198.9	127.4	870.2	1.60
Value Added (\$M)	233.8	109.8	72.9	416.6	1.78
Labor Income (\$M)	135.5	69.5	38.5	243.5	1.80

Source: IMPLAN analysis by Weldon Cooper Center for Public Service

Note: Economic impacts for Virginia are inclusive of Cadence, located in Staunton, Virginia; GO Virginia Region 9 economic impacts include indirect and induced impacts of Cadence.

RESEARCH & DEVELOPMENT PRODUCTIVITY

Productivity of research & development efforts in the CBR through grant and patent awards to active companies since 2010 were tracked from public databases, with support from Randolph Analytics and confirmed in interviews with companies.

TABLE 3. GRANTS AWARDED TO CBR COMPANIES FROM 2010-2019.

GRANTS	# OF AWARDS	AWARD SIZE \$M
CRCF	27	1.9
Virginia Catalyst	8	2.3
SBIR	62	46.9
STTR	7	1.2
Other	16	1.8
TOTAL	120	54.2

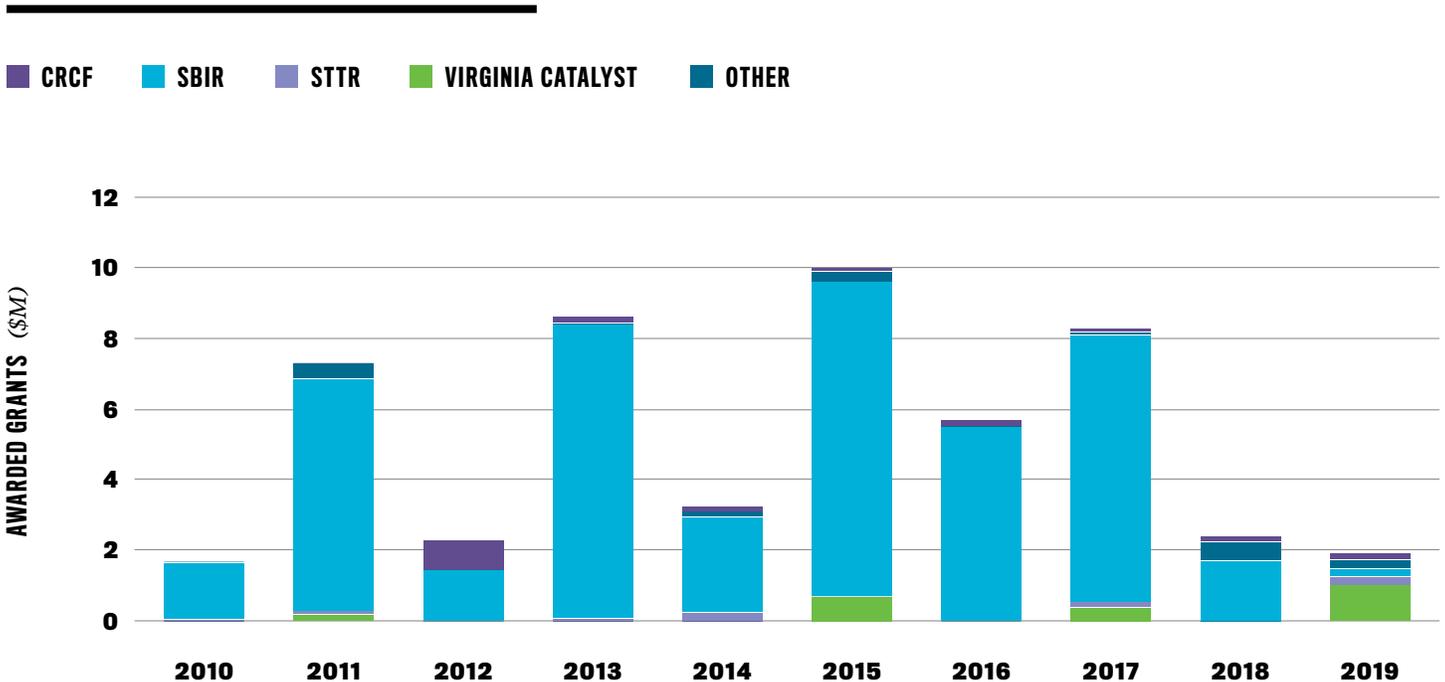
GRANT AWARDS

A total of 24 out of the 67 companies in CBR region have earned more than \$54 million in non-dilutive grant awards in the past 10 years. Grant awards tracked included federal awards from the NIH, NSF SBIR/STTR Virginia-based awards from the Center for Innovative Technology (CIT) as Commonwealth Research Commercialization Fund (CRCF), Virginia Catalyst and other miscellaneous non-dilutive sources of funding (e.g., private foundation support).

The breakdown of awards and trends is shown in **Figure 1**. Of interest, three of the largest recipients of SBIR/STTR awards in the Greater Charlottesville region include **Luna Innovations, Mikro Systems, and HemoShear Therapeutics**. All three companies have been recipients of the National Tibbitts Awards for their models of excellence in the program (SBIR, 2020).

FIGURE 1. TRENDS OF AWARDED GRANTS BY BIOTECH COMPANIES IN CVILLEBIOHUB, 2010-2019.

(Total awards = 120 from 24 companies)

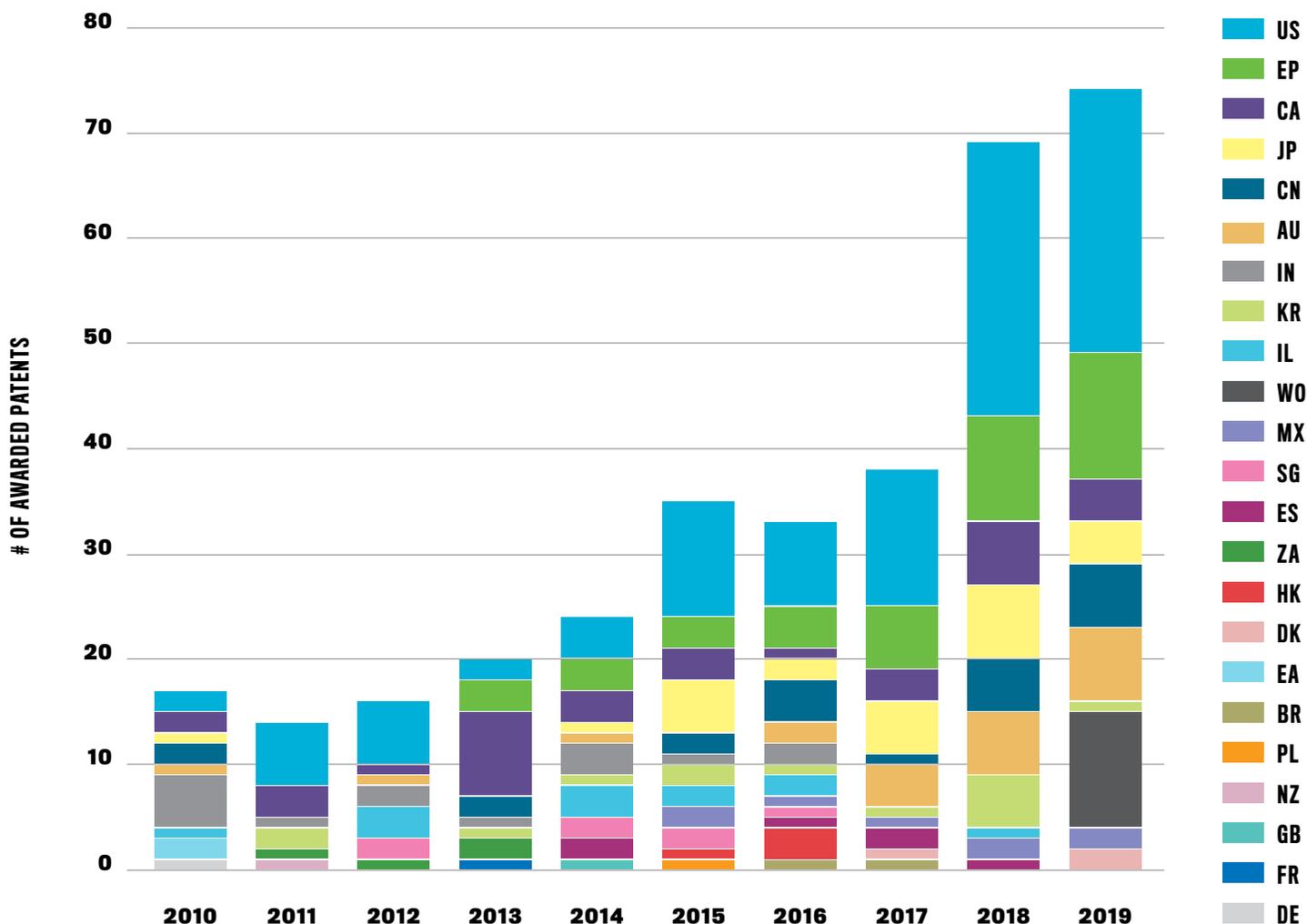


PATENT AWARDS

Productivity of research & development efforts through tracking of patents awarded show that 25 companies, or 37%, in the CBR have been awarded patents in the US, with an upward trend over the past decade (**Figure 2**). Only companies headquartered in CBR were included in this analysis. Diffusion Pharmaceuticals holds the most patents locally, with 86 awards.

FIGURE 2. PATENTS AWARDED BY COUNTRY TO 25 CVILLEBIOHUB BIOTECH COMPANIES, 2010-2019.

(Total awards = 369)



Note: Data generated by Randolph Analytics from publicly available sources.

Financing and Capital Attraction

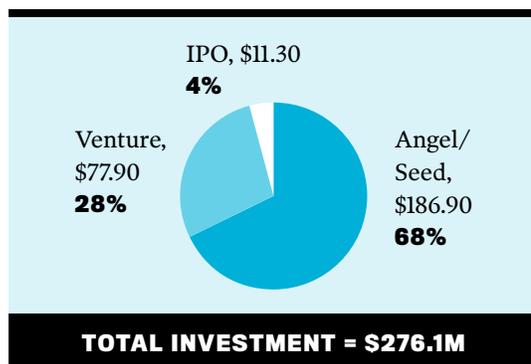
In 2016, Charlottesville was ranked by the National Venture Capital Association as one of the fastest-growing venture capital ecosystems in the U.S. following an analysis of 3,662 companies located in 133 Metropolitan Statistical Areas.

The report showed that Charlottesville experienced the greatest growth of venture capital at 55.2% from 2010 over the 5-year period (Actualize, 2016). There is a strong angel investor community in the CBR, which includes high-net worth individuals, family offices and a few organized investment groups. Collectively, these investors have supported early-stages of many CBR biotechnology companies. These groups include the Charlottesville Angel Network (CAN), Cav Angels and the University of Virginia Licensing & Venture Group Seed Fund (UVA LVG Seed Fund) (**Table 4**).

TABLE 4. EARLY STAGE INVESTMENT GROUPS IN THE CBR.

INVESTOR GROUP	INVESTMENT TYPES	INVESTMENT RANGE	WEBSITE
Charlottesville Angel Network	angel, seed, co-investments	\$100-\$300K	cvilleangelnetwork.net
UVA LVG Seed Fund	seed, co-investments	\$100-\$250K	lvg.virginia.edu
CAV Angels	angel, seed	VARIES	cavangels.com

FIGURE 3. FUNDING OF 27 CVILLEBIOHUB COMPANIES BY SOURCE AND AMOUNT (2010-2019, \$M).



CAPITAL SOURCES AND FUNDING

Twenty-seven companies in CBR have reported raising a total of \$276.1M over the past 10 years. About two-thirds of this funding, or \$187M, has come from angel/seed investors, with about \$78M from venture capital sources and \$11.3M from initial public offerings (**Figure 3**). Additionally, 29 companies in the network also rely upon or are utilizing self-funding, grant awards, and revenue generation for capitalization. Reported funding data from companies and publicly available resources highlight examples of the amount of funds individual CBR companies have received within the last 10 years. (**Table 5**)

TABLE 5. REPORTED CAPITAL RAISED BY BIOTECH COMPANIES IN CBR.

COMPANY	SUBSECTOR	CAPITAL RAISED \$M	CURRENT STAGE
Adial Pharmaceuticals	Therapeutics	6.7	Series A
AgroSpheres	Agriculture & Food Tech	5.2	Series A
Babylon Micro-Farms	Agriculture & Food Tech	5.5	Seed
BrightSpec	Devices & Instrumentation	2.3	Series B
Caretaker Medical	Devices & Instrumentation	3.4	Series A
Cavion	Therapeutics	31.1	M&A
Contraline	Devices & Instrumentation	2.9	Seed
Diffusion Pharmaceuticals	Therapeutics	36	IPO
Locus Health	Devices & Instrumentation	7.2	Series B
TearSolutions	Therapeutics	18.3	Series B
TypeZero Technologies	Devices & Instrumentation	2.6	M&A
Ziel Bio	Therapeutics	25.1	Series A

MERGERS & ACQUISITIONS

Company mergers & acquisitions (M&A) in the region are celebrated, as they are a return on investment for early participating angels and validate the successful entrepreneurial talent in the CBR. With a strong innovation ecosystem, financial and human resources from exited companies can be deployed to found and help create new companies. There were nine notable M&A events that took place in the CBR between 2008 and 2019.

- > **Cavion**, by Jazz Pharmaceuticals, \$52.5M, 2019
- > **BeHealth Solutions**, by Pear Therapeutics, 2019
- > **TypeZero**, by Dexcom, 2018
- > **Medical Automation Systems**, by Alere, 2011 and then by Abbott, \$5.9B, 2017
- > **Adial Pharmaceuticals**, \$7.3M IPO, 2016
- > **Phosimmune** by Aegenus, \$44M, 2015
- > **Adenosine Therapeutics**, by Clinical Data, \$22M, 2008

Infrastructure and Facilities

Biotech industry infrastructure often comes with specific needs, especially for life science companies that require liquid and specimen handling (i.e., wet lab environment).

TABLE 6. BREAKDOWN OF OCCUPIED SQUARE FOOTAGE BY BIOTECH INDUSTRY IN THE CBR.

FACILITY TYPE	OCCUPIED FOOTPRINT <i>sf</i>
Class A Office	143,900
Wet Lab	261,600
Dry Lab/Manufacturing	434,300
TOTAL	839,800

Specialty needs may include unique air handling systems, redundant backup power, purified water, sterilizers, and fume hoods. Total occupied footprint of space by the biotech industry in CBR is 834,100 square feet, with 30 percent of the square footage classified as wet lab facilities (Table 5). In the past 10 years, several premier state-of-the-art laboratories have been built and outfitted, including **Afton Scientific** (30,000 sf), **HemoShear Therapeutics** (16,000 sf), **Indoor Biotechnologies** (13,200 sf), **Contraline** (4,200 sf) and **Lumacyte** (6,500 sf).

Currently, there is no available leasable wet lab space in the city of Charlottesville. Companies are occupying and retro-fitting historic buildings or class B spaces that were not intended for laboratory use. There are no incubator-style lab facilities where companies can lease smaller footprint spaces to demonstrate feasibility of concept and then expand into larger space as needed. If the biotechnology industry in the CBR is to double in size over the next 10 years, it will need at least 500,000sf of space. Charlottesville has about 300,000sf of Class A office space under construction in the CODE, Dairy Market and 3Twenty3 buildings which will accommodate consulting, CRO, management and financial companies in the biotech sector. The main priority is to develop incubator space, wet-lab and small-scale pilot manufacturing facilities for growing companies. CvilleBioHub is supported by GO Virginia to develop a wet lab incubator model and development plan that could be implemented within the CBR with supported funding.

UVA RESEARCH PARK

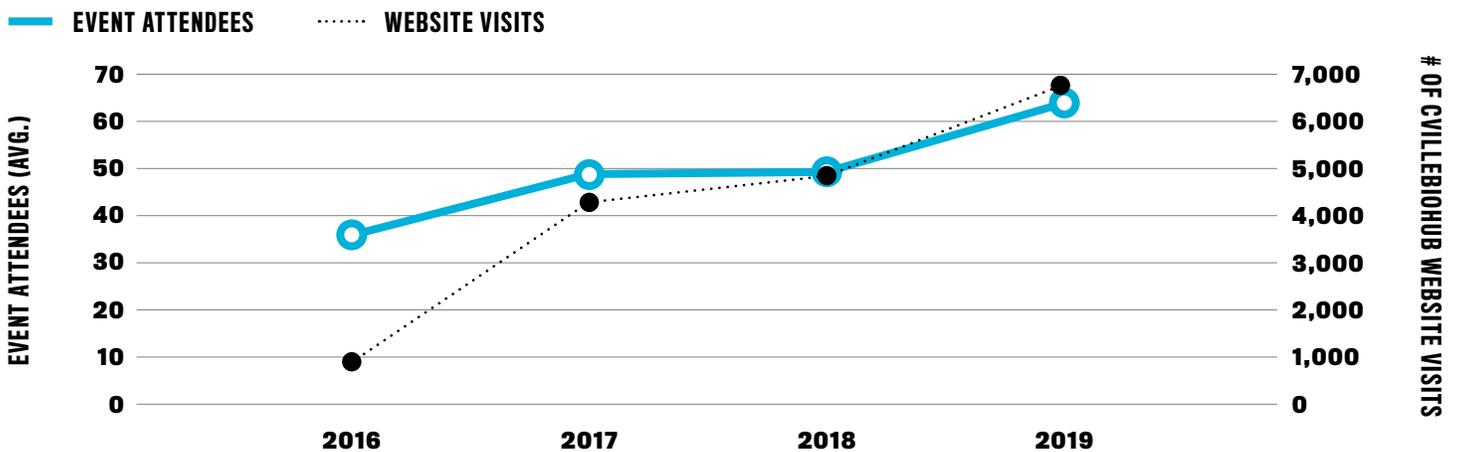
The UVA Research Park is located in Albemarle County (9 miles north of the UVA main campus) offering flexible workspaces and mixed-use development zoned for office, light industry, conference center, laboratory, and retail/support commercial uses. Currently, six companies in the CvilleBioHub network occupy over 130,000 square feet of office and lab space in the Park: **Adial Pharmaceuticals**, **Agenus**, **Bonumose**, **PRA Health Sciences**, **Signature Science**, and **MITRE**.

Activity in the CvilleBioHub Network

CvilleBioHub creates pathways for connection and education of the local biotech and health tech industry.

CvillebioHub's website (www.cvillebiohub.org) highlights local companies, industry metrics and events that build the community and promote local companies. Engagement across the web platform and through community events has progressively increased (Figure 6). In 2019, there were more than 6,700 visits to the website, a 39% increase over 2018. The most popular page on the site features profiles of companies in the network, which demonstrates strong demand for information about member companies. CvilleBioHub has also attracted nearly 1,000 people to sign up to receive our monthly newsletters and our social media outreach often gains over 1,000 views for posts.

FIGURE 4. ACTIVITY TRENDS IN CVILLEBIOHUB, 2016-2019.



CvilleBioHub is a major community partner and many partnerships were strengthened in 2019 as a result of its awarded GO Virginia Enhanced Capacity Building Grant. New and continued partnerships include: Albemarle County Economic Development, Central Virginia Partnership for Economic Development, City of Charlottesville Economic Development, Quantitative Foundation, University of Virginia Economic Development, and University of Virginia Licensing & Ventures Group. Additional supporters include HackCville, Louisa County Economic Development, Piedmont Virginia Community College, UVA PhD Plus Program, and Storyware.

**NATIONALLY, <10%
OF BIOTECH CEOS
ARE WOMEN AND
EVEN FEWER ARE
MINORITIES.**

CvilleBioHub is primed to play a major role in providing resources, space and community connections to all companies in the network, supporting all stages of biotechnology companies. Successes in commercialization can be directly impacted by CvilleBioHub through programming and partnerships with the University of Virginia.

REPRESENTATION OF WOMEN AND MINORITIES

In the biotech industry in the CBR, as with most high-tech industries, women and minorities are underrepresented compared to their proportion in the general population, especially as founders and in leadership and executive roles. Nationally, the same is true for the biotechnology and life sciences industry, where <10% of CEOs are women and even fewer are minorities. Organizations such as “Women in Bio” raise awareness and promote gender equality. UVA is recognized as a top public engineering school in the country for women earning degrees in the field and the UVA Office of Diversity and Engagement offers pathways and programs for underrepresented populations to become leaders in science and technology. An ad hoc analysis of women in leadership roles in companies within the CBR reveals 10 companies with women founders, CEO’s and/or women in senior leadership roles (**AMPEL Biosolutions, HKL Research, Imbibe Solutions, Indoor Biotechnologies, KeViRx, Lumacyte, Positivelinks, Sarnaya, Vibratess and ZielBio**). At approximately 15%, representation of women leaders in the CBR is higher than the national average, albeit with plenty of room for improvement. CvilleBioHub pro-active in promoting women as speakers and panelists at events and discussion forums and through hosting student visits to local companies and internships. Notwithstanding these efforts, much remains to be done.

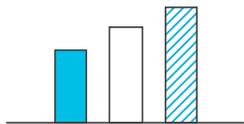
Representation of minorities in STEM fields nationally and within the CBR is a major challenge. Typically, fewer African-American, Hispanic and Native American students graduate in STEM fields or pursue graduate degrees (PhDs and MBAs) that are essential for careers in the biotech industry. Regrettably, representation of minorities in leadership positions within the CBR is depressingly low (<1%). Solutions to improve this representation include actively promoting STEM in minority populations in K-12 education, colleges and universities and pro-actively promoting internships among minority students to increase their exposure to biotech career opportunities. Hosting site visits and inviting diversity groups at local universities allows minority students access to biotech companies and encourages students to pursue careers in STEM fields.

Industry Report Findings

As a result of academic strength and support at the University of Virginia, an intellectually rich community, and angel investment participation, biotechnology innovation in CBR area is very strong, and undeniably growing.

Scientific and technological advancements are catching up with significant unmet needs in human health, offering incredible growth and opportunity for the biotechnology industry globally. CvilleBioHub companies are contributing locally and thriving. Among the findings:

71 companies in the BioHub; **45 COMPANIES** with UVA affiliation



\$330M

in support; including **\$256M** in private, angel and venture capital investments and **\$54M** of non-dilutive grant awards

369 patents held in the BioHub Network

CvilleBioHub and Weldon Cooper Center have conducted the assessment of the local industry from which future activity and growth can be measured. An outcome of this report is to set a benchmark for future metrics on biotech industry cluster growth in CBR.

- > **Talent:** Companies and organizations report **1,950** employees in the CvilleBioHub Region. For every biotech job in the region, 1.7 more jobs are created. The average annual salary for biotech employees is **\$93,450**, which is 1.9 times greater than the regional average for all other industries.
- > **Impact:** The economic impact of the CvilleBioHub Region (the statewide service region) is **5,261** jobs and **\$1.2B** of activity. These values reflect high economic multipliers and are above average compared to other industries in the region.
- > **Capital:** Companies have financed their efforts through more than **\$330M** in support, which includes **\$276M** in private, angel and venture capital investments and **\$54M** of non-dilutive grant awards.
- > **Infrastructure and Facilities:** The industry occupies **839,800 sf** of space, primarily in proximity to UVA and downtown Charlottesville, with 130,000 sf of space occupied in the UVA Research Park that serves mature companies. The CvilleBioHub remains deficient in space to serve current emerging companies and lacks sufficient wet lab infrastructure for emerging life sciences companies.
- > **Mergers & Acquisitions:** Nine major acquisitions or Initial Public Offerings were announced between 2008-2019. Such outcomes are signals of attractive and innovative technologies being developed for the marketplace and thus, economic strength, where experienced talent is then re-circulated into the growing ecosystem.

As the field evolves and as larger successes take place locally, the biotech industry cluster in CBR has the opportunity to be a leading Virginia ecosystem where scientists and business people seek new opportunities in developing new biotech companies and a high quality of life.

Appendix A. Supplemental CvilleBioHub Data

TABLE I. CVILLEBIOHUB COMPANIES AND OVERVIEW METRICS.

COMPANY	YEAR ESTABLISHED	SUBSECTOR	# OF EMPLOYEES	OCCUPIED FOOTPRINT sf	WEBSITE
Abbott Rapid Diagnostics (formerly Alere, Medical Automation Systems)	1994	Devices & Instrumentation	100	23,000	https://www.abbott.com/
Adial Pharmaceuticals	2011	Therapeutics	3	500	https://www.adialpharma.com/
Afton Scientific	1990	Biomanufacturing	50	30,000	http://www.aftonscientific.com/
Agenus (formerly PhosImmune)	2012	Therapeutics	3	3,000	https://agenusbio.com/
AgroSpheres	2016	Agriculture & Food Tech	6	3,000	https://www.agrospheres.com/
Alexander BioDiscoveries	2009	Therapeutics	1	-	-
AMPEL BioSolutions, LLC	2013	Therapeutics	18	2,500	http://ampelbiosolutions.com/
ArcheMedX	2012	Health Tech & Software	12	3,600	https://www.archemedx.com/
Atheric™ Pharmaceutical LLC	2016	Therapeutics	1	-	-
Atlantic Research Group	2004	Clinical Research	100	12,000	https://atlanticresearchgroup.com/
AXON Dx™	2013	Devices & Instrumentation	15	10,000	http://axondx.com/
Babylon Micro-Farms Inc.	2017	Agriculture & Food Tech	5	2,500	https://www.babylonmicrofarms.com/
BeHealth Solutions	2011	Health Tech & Software	3	-	https://www.behealthsolutions.com/
BIO-CAT	1988	Biomanufacturing	45	75,000	https://www.bio-cat.com/
Bonumose Biochem, LLC	2016	Agriculture & Food Tech	7	3,500	https://bonumose.com/

Continued on Page 22

COMPANY	YEAR ESTABLISHED	SUBSECTOR	# OF EMPLOYEES	OCCUPIED FOOTPRINT sf	WEBSITE
BrachyFoam, LLC	2017	Devices & Instrumentation	4	500	https://brachyfoamproducts.com/
BrightSpec, Inc.	2012	Devices & Instrumentation	10	5,000	http://brightspec.com/
Cadence (formerly Specialty Blades)	1985	Devices & Instrumentation	500	250,000	https://www.cadenceinc.com/
Caretaker Medical	2014	Devices & Instrumentation	8	4,200	https://www.caretakermedical.net/
Center for Open Science	2013	Foundations & Education	45	8,800	https://cos.io/
Cerillo	2016	Devices & Instrumentation	2	1,600	https://cerillo.net/
Contraline	2015	Devices & Instrumentation	8	4,600	http://www.contraline.com/
Diffusion Pharmaceuticals, Inc.	2001	Therapeutics	10	5,000	https://www.diffusionpharma.com/
Direct Spinal Therapeutics, Inc.	2013	Devices & Instrumentation	1	-	-
Fiacre Enterprises	2018	Agriculture & Food Tech	2	-	https://fiacre-enterprises.com/
Focused Ultrasound Foundation	2006	Foundations & Education	35	9,300	https://fusfoundation.org/
HemoShear Therapeutics, LLC	2008	Therapeutics	25	16,000	https://hemoshear.com/
HemoSonics, LLC (acquired by Stago Group)	2009	Devices & Instrumentation	10	5,500	https://hemosonics.com/
HKL Research, Inc.	1995	Health Tech & Software	2	1,200	https://hkl-xray.com/
Imbibe Solutions	2015	Agriculture & Food Tech	1	-	https://imbibe-solutions.com/
Indoor Biotechnologies, Inc.	1997	Biomanufacturing	22	13,200	https://inbio.com/
Keswick Pharmaceuticals		Consulting	1	-	-
KeViRx	2017	Therapeutics	4	500	http://www.kevirx.com/
Lighthouse Instruments	1995	Devices & Instrumentation	35	42,000	https://www.lighthouseinstruments.com/

Continued on Page 23

COMPANY	YEAR ESTABLISHED	SUBSECTOR	# OF EMPLOYEES	OCCUPIED FOOTPRINT sf	WEBSITE
Locus Health	2009	Health Tech & Software	45	7,500	https://www.locushealth.com/
LumaCyte	2012	Devices & Instrumentation	12	2,500	https://www.lumacyte.com/
Luna Innovations	1990	Devices & Instrumentation	42	8,000	https://lunainc.com/
Lytos Tech	2018	Agriculture & Food Tech	2	1,350	https://www.lytostech.com/
Medical Predictive Science Corp	2003	Health Tech & Software	7	1,500	https://www.heroscore.com/
MicroAire Surgical Instruments	1979	Devices & Instrumentation	152	100,000	https://www.microaire.com/
MicroGem	2015	Devices & Instrumentation	31	7,500	https://microgembio.com/
Mikro Systems, Inc.	2000	Devices & Instrumentation	90	30,000	http://www.mikrosystems.com/
Minus80 Monitoring, LLC	2012	Devices & Instrumentation	3	-	https://minus80monitoring.com/
MIST, LLC	2018	Devices & Instrumentation	3	-	https://www.minspinaltech.com/
NDA Partners	2003	Consulting	6	-	https://ndapartners.com/
Neurodegeneration Therapeutics	2015	Foundations & Education	1	-	http://ndtherapeutics.org/
Neuroview	2019	Health Tech & Software	2	-	https://www.neuroview.co/
Gencia	1990	Therapeutics	3	1,600	-
PRA Health Sciences	1976	Clinical Research	253	55,000	https://prahs.com/
PurSolutions, LLC	2015	Biomanufacturing	3	800	https://puresoluble.com/
Revive Pharmaceuticals		Therapeutics	1	1,500	https://www.revivepharma.com/
Rivanna Medical	2010	Devices & Instrumentation	23	5,000	https://rivannamedical.com/
SafeSharp	2016	Devices & Instrumentation	1	-	http://www.safesharp.com/

Continued on Page 24

COMPANY	YEAR ESTABLISHED	SUBSECTOR	# OF EMPLOYEES	OCCUPIED FOOTPRINT sf	WEBSITE
Scanoptix	2019	Health Tech & Software	1	-	http://www.scanoptix.com/
Scivera	2008	Consulting	12	-	https://www.scivera.com/
Silivhere	2015	Devices & Instrumentation	1	-	https://www.madidrop.com/
Seraphic Group, Inc.	2015	Agriculture & Food Tech	55	60,000	http://www.seraphicgroup.com/
Signature Science LLC	2001	Consulting	26	5,000	http://www.signaturescience.com/
Soteria Transporters, LLC	2018	Devices & Instrumentation	2	-	-
SoundPipe Therapeutics	2013	Devices & Instrumentation	2	950	https://www.sound-pipe.com/
Springbok Analytics		Health Tech & Software	3	-	http://www.springbokanalytics.com/
TearSolutions, Inc.	2013	Therapeutics	6	-	https://tearsolutions.com/
Toxicology Regulatory Services	1991	Consulting	10	5,000	http://www.toxregserv.com/
TypeZero Technologies, LLC (acquired by DexCom)	2013	Health Tech & Software	15	2,500	https://www.dexcom.com/
Varian Medical Systems	1948	Devices & Instrumentation	30	1,500	https://www.varian.com/
Vibratess, LLC	2007	Devices & Instrumentation	9	1,500	https://www.vibratess.com/
ZielBio	2019	Therapeutics	4	1,000	https://zielbio.com/

Appendix C. Highlights from CBR in 2019

- > **Adial Pharmaceuticals Announces Collaboration Agreement With Eurofins For Genetic Biomarker Testing To Support Upcoming PHASE 3 Clinical Trial for Alcohol Use Disorder** (May 7, 2019)
- > **Diffusion Pharmaceuticals Inc. Announces Closing of \$6.45 Million Offering Priced At-the-Market** (May 28, 2019)
- > **Q&A UVA Today: UVA-Trained Biotech Leader Setting Her Sights On Lupus** (May 28, 2019)
- > **HemoShear Therapeutics names Kathleen Metters to Board of Directors** (June 19, 2019)
- > **UVA Venture Group Keeps Rolling With a Local Biotech Investment** (June 20, 2019)
- > **Jazz Pharmaceuticals Acquires Cavion, for Up To \$312.5M** (August 13, 2019)
- > **HemoShear Therapeutics Appoints Brian A. Johns, PhD, Chief Scientific Officer** (September 25, 2019)
- > **ZielBio Closes \$25.1 Million Series A Funding to Enable Development of Monoclonal Antibody ZB131** (September 26, 2019)

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