



Maryland: The Nation's Bioscience Leader

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Submitted to:
Comptroller of Maryland

December 2007

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Executive Summary

Objective

Sage Policy Group, Inc., an economic and policy consulting firm in Baltimore, MD, authored this analysis of the economic and fiscal contributions of Maryland's bioscience industry on behalf of the Maryland Office of the Comptroller. In order to conduct its analysis, Sage utilized publicly available data/information and standard analytical techniques.

Findings

The story of biosciences in Maryland is rooted in its unmatched capacity to engage in basic research that investigates the nature of life. From this research has sprung an ongoing stream of basic knowledge, protocols and technologies that have not only revolutionized our understanding of life at its most fundamental levels, but have also given rise to products and services of enormous and growing commercial value.

Various reports often short-change Maryland's bioscience sector. For instance, the well-known and heavily quoted Ernst & Young's Global Biotechnology Report measures the size of a particular state's biotech sector according to the number of significantly-sized companies operating in the industry. In recent reports, Maryland has ranked fourth in terms of biotech firm concentration, behind California, Massachusetts and North Carolina.

But these types of rankings fail to reflect Maryland's greatest competitive advantage, which is its massive supply of institutional research. By being home to NIH, FDA, Johns Hopkins, the University of Maryland-Baltimore, Fort Detrick and many other institutions operating at the cutting edge of the life sciences, Maryland represents perhaps the greatest concentration of bioscience research in the world.

This report's primary contribution revolves around its use of a sufficiently broad definition of bioscience in Maryland. Sage's analysis measures the economic and fiscal contributions of both private bioscience enterprises and institutional employees directly engaged in research and development activities.

Based on this analysis, the study team concludes that Maryland's bioscience sector is among the nation's largest, if not the largest, generating \$29 billion in economic output, supporting 120,000 total jobs, \$11 billion in income and nearly \$600 million in State government taxes annually. Jobs supported directly by the state's life sciences industry pay \$108,000/annum on average. Almost one-fifth of bioscience workers hold doctorates and over half have graduates degrees. In other words, the sector supports nearly 5 percent of Maryland's total employment, more than 8 percent of its wage/salary income, and over 11 percent of gross state product. The exhibit below summarizes the study team's major quantitative findings.

Exhibit E1: Summary of economic and fiscal impacts of the bioscience industry on Maryland

| <i>Type of Impact</i> | <i>Total (direct, indirect and induced) Impact (dollars in millions)</i> |
|--------------------------------------|------------------------------------------------------------------------------|
| Employment | 120,341 |
| Wage Income | \$11,241 |
| Gross State Product (business sales) | \$29,230 |
| State of Maryland Tax Revenues | \$570 |

Additional and rapid expansion is forthcoming. The global investment community has taken notice of Maryland’s enormous potential for commercialization and profitability. Conventional wisdom holds that investment funds seek to invest where money is best treated.

Based on this, it is clear that investors believe Maryland holds great promise. The *number* of life sciences-oriented venture capital deals in the Washington-Baltimore metro area increased 121.5 percent from the 1997-2001 period to the 2002-2006 period, the best performance in the U.S. and much higher than the second place region, San Francisco, where the number of deals increased a relatively lackluster 37.7 percent. The *value* of life-science oriented venture capital invested in the Washington-Baltimore metro area increased 134.3 percent from the 1997-2001 period to the 2002-2006 period. Again this was the highest increase in the nation and well above the second place area, Boston/New England where the value of venture capital investment increased 90.0 percent.

Over the next decade, Maryland’s biotech sector is poised to become even more globally pre-eminent. The development of two biotechnology parks in Baltimore City in conjunction with the massive and expanding life sciences cluster in Maryland’s D.C. Suburbs may be enough to push Maryland past Massachusetts and California assuming that Maryland isn’t already number one. Indeed, given its vast institutional presence (e.g., NIH, FDA, JHU, NIST, Fort Detrick, UMB, UMBI), Maryland may already be number one in terms of the size of its broadly defined bioscience sector. One would have to study only California and Massachusetts to confirm this.

Policymakers could do much to improve Maryland’s competitive profile and biotech business environment. For instance, Maryland can and should follow the lead of other states that allocate a higher percentage of State pension fund dollars toward investment in technology industries. The State could also add tax incentive programs to encourage private sector investment in the state as well as increase funding (dramatically, e.g., 70 percent) for its seed funding programs – TEDCO, DBED’s Maryland Venture Fund and UMCP’s MIPS program.

Introduction

Purpose

Sage Policy Group, Inc. conducted this analysis of Maryland's bioscience sector in order to determine just how large and important this industry is today.¹ The report also highlights some of the sector's major contributions, companies and institutional drivers.

Other life sciences reports typically adopt a narrower focus. For instance, the well-known and heavily quoted Ernst & Young's Global Biotechnology Report measures the size of a particular state's biotech sector according to the number of significantly-sized companies operating in the industry. In recent reports, Maryland has ranked fourth in terms of biotech firm concentration, behind California, Massachusetts and North Carolina.

By contrast, this report adopts a broader approach to quantifying the size and import of the local bioscience industry by measuring the economic and fiscal impacts of both private and institutional life science entities. Maryland, of course, is especially advantaged in terms of the presence of large institutional players, including NIH, Johns Hopkins, FDA², the University of Maryland among many others.

Defining Bioscience

Bioscience has come to mean different things to different people. Some observers concentrate on the sector's innovative and technical aspects. For instance, the Biotechnology Industry Organization defines biotechnology as "a collection of technologies that capitalize on the attributes of cells, such as their manufacturing capabilities, and put biological molecules, such as DNA and proteins, to work for us."³

MdBio, a private non-profit corporation that seeks to advance Maryland's bioscience industry takes a more expansive view.⁴ In its recent report regarding Maryland's life sciences industry, MdBio defines bioscience organizations as those involved in the research, development, or manufacture of:

1. biologically active molecules;
2. devices that employ or affect biological processes;
3. biological information resources; or
4. software designed specifically for biological applications.

This paper adopts a broader definition by realistically supplementing the companies and organizations that would be included according to the two definitions above by adding a

¹ For purposes of this discussion, Sage has used the terms bioscience, life sciences and biotech interchangeably unless otherwise noted.

² Food and Drug Administration.

³ Biotechnology Industry Organization, "What Is Biotechnology?" www.bio.org

⁴ MdBio, "Bioscience in Maryland 2007," www.mdbio.org

variety of organizations and institutions that directly support the sector's capacity for innovation and expansion. Prominent among these are Maryland-based financiers that specialize in biosciences; technology/business incubators that help sustain fledgling life science firms; institutions that train the highly-specialized labor employed by the sector and firms that deliver specialized professional services targeted directly toward satisfying the particular needs of bioscience entities.

This definition should not be viewed as overly broad. The complexity of the bioscience sector is reflected in the composition of the Maryland Life Sciences Advisory Board recently created by Governor Martin O'Malley.⁵ Tasked with the creation of a comprehensive strategic plan for the promotion of Maryland's life sciences industry, the Board comprises 15 members representing:

- Bioscience companies;
- Research universities;
- Federal laboratories;
- State economic development agencies;
- Local economic development agencies;
- Community colleges; and
- Real estate developers;

In announcing the Board, the governor also recognized the importance of biosciences as a critical Maryland economic driver. Salient facts include:

- More than 370 bioscience companies operate in the state;
- Approximately 30,000 private-sector bioscience jobs are supported by these companies;
- Another 30,000 jobs are supported in related federal and academic institutions;
- Over \$450 million in state long-term investment in bioscience infrastructure has been made;
- Maryland ranks second globally in terms of its aggressive appeal to attract and retain bioscience companies;⁶
- Maryland ranks second in the U.S. for biopharmaceutical innovation;⁷ and
- Maryland is cited as one of the nation's top three centers for biodefense.⁸

An already large industry with vast potential

The story of biosciences in Maryland is essentially rooted in its unmatched capacity to engage in basic research that investigates the nature of life. From this research has sprung an ongoing stream of basic knowledge, protocols and technologies that have not

⁵ Office of the Governor, "Governor O'Malley announces Maryland Life Sciences Advisory Board," press release, September 14, 2007.

⁶ Id. These initiatives include building research parks, investing public funds, and providing tax incentives.

⁷ Id. Ranking made by the Milken Institute.

⁸ Id. Ranking made by Ernst & Young.

only revolutionized our understanding of life at its most fundamental levels, but have also given rise to products and services of enormous and growing commercial value. As we come to better understand the processes by which knowledge developed in the laboratory is transferred to the marketplace, the economic contributions of the state's bioscience sector will continue to expand. Marylanders have in recent years adopted a much more aggressive stance toward technology transfer, and this prioritization is likely to yield enormous benefits going forward.

The Composition of Maryland's Life Sciences Sector Today

It can be argued that more than any other significant segment of the local economy, biosciences is dependent upon the continuous generation of knowledge. Yet knowledge in and of itself has little utility from a strictly economic/business perspective. In this context, the private sector's principal role is to identify the practical applications of knowledge, and then translate those applications into workable business plans/models.

Institutions Engaged in Basic Research

If the key to future economic prosperity is knowledge, then Maryland's bioscience sector is in a uniquely privileged position. Home to almost 90 federal laboratories and key research universities, Maryland has unparalleled intellectual resources that have spawned numerous companies, particularly in the life sciences.⁹

The clearest competitive advantage Maryland has in basic research is the National Institutes of Health located in Montgomery County. With over 18,000 employees and a budget of \$28 billion, NIH is the nation's leading medical research agency and the primary source of medical research funding.

The critical and vital role of the NIH in fueling the world's advances in medical and scientific knowledge is reflected in the Nobel Prizes awarded to scientists employed or supported by NIH. In the past 50 years, these researchers have won 114 Nobles prizes. In that half century, NIH-supported scientists have received one or more Nobel prizes in 45 of 50 years.

If NIH represents the greatest concentration of medical researchers in the world, then the Food and Drug Administration (FDA; headquartered in Rockville, MD) represents the gatekeeper charged with determining which innovations emerging from NIH, Maryland bioscience companies, or elsewhere enters the marketplace. Charged with "protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, [and] medical devices," FDA implements a regulatory framework that all pharmaceutical products must undergo. The principal regulatory pathway is the clinical trial—a three-stage research study that tests the safety and/or effectiveness of drugs, vaccines, other therapies, or new ways of using existing treatments in people. Clinical trials take years and most drugs do not pass muster. A fourth stage of clinical

⁹ Economic Alliance of Baltimore, "Biosciences in Greater Baltimore," June 2007.

trials assesses products that are available in the marketplace. Immediate and ready access to the FDA represents a unique competitive advantage for biosciences in Maryland that simply cannot be duplicated anywhere else in the world.¹⁰

In addition to NIH and FDA, there are other federal agencies that have proven to be particularly instrumental in the development of Maryland's bioscience sector. For instance, Walter Reed Army Institute, the Naval Medical Research Institute, and the Uniformed Services University of Health Sciences represent a triumvirate of medical and health research and services dedicated to the U.S. military services. Out of the devastation of the current war in Iraq, for example, have come remarkable advances in motorized prosthetic limbs that can respond directly to the brain's signals. This technology was developed by a team that included staff from Walter Reed.¹¹ The U.S. Army Medical Research Institute of Infectious diseases at Fort Detrick outside of Frederick is the lead federal agency for biodefense vaccine research and a major reason for Maryland's preeminence in the field of biodefense.

The other major driver of basic research in Maryland is academia, including of course the state's major research universities. In 2005, the NIH awarded \$835 million to Maryland universities. The unrivaled leader in NIH awards in Maryland, and indeed in the U.S., is Johns Hopkins University (JHU), which was awarded \$607 million that year—29 percent more than the second-ranked university. Another \$228 million was awarded to four University of Maryland institutions, with \$182 million directed to the University of Maryland, Baltimore.¹²

One measure of the value of basic research at these public and private institutions is their propensity to generate new companies founded upon the intellectual capital developed in their laboratories. Maryland's major research institutions have been the primary source of leadership at new bioscience companies, although large companies and even foreign countries also make substantial contributions.¹³ As shown in Exhibit 1, among the state's major research centers, NIH is the most common source of company founders, followed by the state's two leading research universities.

¹⁰ U.S. Food and Drug Administration web site, www.fda.gov

¹¹ "Science extends reach of prosthetic arms," Medical News Today, November 12, 2007, www.Medicalnewstoday.com.

¹² National Science Foundation, 2007 as reported in *op.cit.*, Economic Alliance of Greater Baltimore. The University of Maryland—College Park received \$23 million, UM's Biotech Institute was awarded \$14 million, and UM Baltimore County received \$9 million.

¹³ *Op.cit.*, Economic Alliance of Greater Baltimore. Large companies were the source of founders of 40 bioscience companies and the founders of 25 companies had strong ties to foreign countries.

Exhibit 1: Links between research centers and bioscience companies

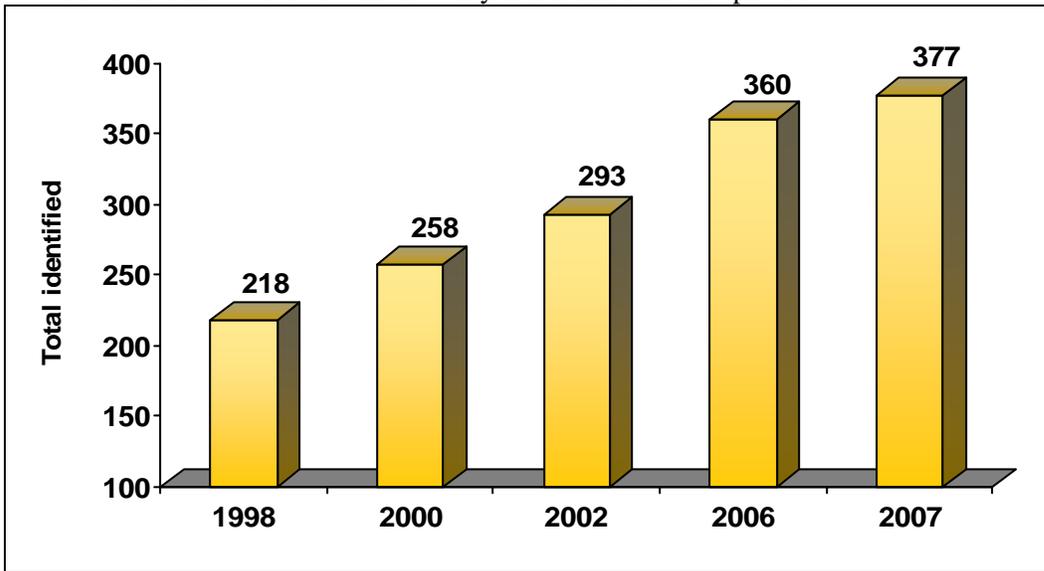
| <i>Research center</i> | <i>Maryland bioscience companies with strong founder ties</i> |
|--------------------------------------------------|---------------------------------------------------------------|
| National Institutes of Health | 41 |
| Johns Hopkins University | 34 |
| University of Maryland | 27 |
| Walter Reed Army Institute | 11 |
| Uniformed Services University of Health Sciences | 5 |
| Naval Medical Research Institute | 5 |

Source: Economic Alliance of Baltimore, "Biosciences in Greater Baltimore," June 2007.

Private Sector Companies

The transformation of expanding knowledge and technological capabilities into commercial ventures has steadily generated a growing number of bioscience companies. As of late 2007, there were at least 377 bioscience companies operating in Maryland.¹⁴ This represents a 73 percent increase since 1998, when 218 identifiable bioscience companies were operating statewide. On average the number of companies operating in the life sciences space has increased 6.3 percent annually over that period.

Exhibit 2: Growth in the number of Maryland bioscience companies



Source: MdBio

Not surprisingly, many of these companies are clustered around the state's research institutions, another reason to adopt a broader (cluster-based) industry definition than is typically utilized. Montgomery County, home to NIH, FDA, NIST¹⁵ among other relevant institutions, is home to 55 percent of the state's biotech firms. The Baltimore

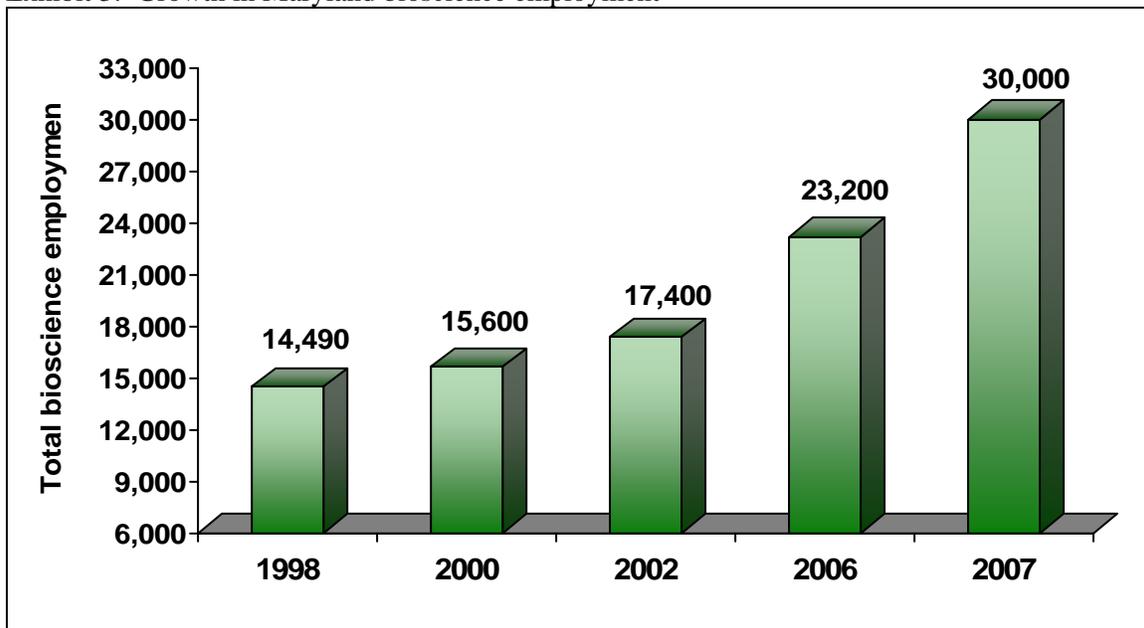
¹⁴ The current list of MdBio members totals 377 companies. As MdBio is the principal statewide organization supporting the industry, its membership serves as a reasonable census of bioscience companies in Maryland.

¹⁵ National Institute of Standards and Technology.

area, home to the states two largest research universities in the biosciences, is home to 23 percent of Maryland’s bioscience firms.¹⁶ Frederick County, which benefits from its link to Montgomery County via the I-270 corridor and the presence of Fort Detrick, is home to 15 percent of Maryland’s biotech companies.

Employment among bioscience companies has expanded steadily over the past decade, roughly doubling between 1998 and 2007. Since 1998, employment has grown at an average annual rate of 8.4 percent, significantly higher than the average annual growth rate for all Maryland companies (1.3%).

Exhibit 3: Growth in Maryland bioscience employment



Sources: MdBio for data for 1998-2006, Office of the Governor for 2007 data

¹⁶ *Op. cit.*, MdBio

As of late 2006, there were 22 public bioscience companies with headquarters in Maryland. Collectively, these companies possessed a market value exceeding \$15 billion.

Exhibit 4: Publicly traded bioscience companies headquartered in Maryland

| <i>Company</i> | <i>Market value * (millions)</i> |
|-------------------------------------------------------------|----------------------------------|
| Advancis Pharmaceuticals | \$131 |
| Avalon Pharmaceuticals | \$31 |
| Bioelectronics Corporation | \$6 |
| Bioveris Corporation | \$260 |
| Ceptor Corporation | \$3 |
| Celsion Corporation | \$29 |
| Applera-Celera Corporation | \$1,140 |
| Digene Corporation | \$1,130 |
| EntreMed, Inc. | \$147 |
| GeneLogic Inc. | \$53 |
| GenVec Inc. | \$102 |
| Human Genome Sciences | \$1,700 |
| Hemagen Diagnostics | \$4 |
| Igene Biotechnologies Inc. | \$3 |
| Iomai Corporation | \$86 |
| Martek Bioscience | \$764 |
| MedImmune Inc. | \$7,280 |
| Osiris Therapeutics | \$422 |
| Regenerx Biopharmaceuticals | \$90 |
| Rexahn Pharmaceuticals | \$90 |
| United Therapeutics | \$1,400 |
| Vanda Pharmaceuticals | \$278 |
| Note. Market capitalization value is as of October 26, 2006 | |
| Source: MdBio | |

Bioscience companies engage in a wildly varied set of activities. Most companies specialize in a limited number of technologies and/or services. Despite the breadth of endeavor, the myriad of technologies and services can be grouped into a few broad categories—therapeutic companies, service companies, and tools and diagnostics companies.

Therapeutic companies. Therapeutic companies are in the business of developing, manufacturing, and/or distributing new treatments for diseases. In the words of MdBio, they are the “indisputable stars” of the bioscience industry with the potential to transform medical practice and generate spectacular returns for investors and founders. It is not enough, however, for these firms to develop new technologies and therapies. The challenge for many of these enterprises is to also build businesses capable of surviving, thriving and marketing in the new economy.

Remarkably, half of all Maryland bioscience businesses are classified as therapeutic companies despite the obvious challenges of innovation. One particularly challenging aspect associated with bringing a novel product to market is the long, expensive and arduous multiphase process associated with FDA approval for new pharmaceutical products. By 2006, only seven therapeutic products developed by Maryland bioscience companies had completed the three-phase FDA approval process and received FDA approval. Still, a few approved products can be associated with a massive amount of revenues. Five of these approved products generated a combined \$1.32 billion in revenues in 2005, an increase of 12 percent over corresponding 2004 revenues.¹⁷

Given the pipeline of products under development, the collective future of Maryland's therapeutic companies appears promising.¹⁸ Recently, a total of 69 therapeutic products were in FDA trials (including eight in the final Phase III studies) and another four products had filed applications to undergo these trials.¹⁹ Below is a brief history of one of Maryland's most renowned and respective therapeutic companies.

Founded in 1988, **MedImmune, Inc.** is a clear leader among Maryland's bioscience companies. With 3,000 employees, the company has expanded beyond its Maryland base to facilities in three other states and in the United Kingdom and Netherlands. MedImmune itself owns four of the seven FDA-approved therapeutics produced by Maryland-based companies. Since 1998, when its first drug received FDA approval, revenues have risen from \$227 million to \$1.3 billion in 2006.

The company operates out of a 220,000 square-foot facility in Gaithersburg at a site with the potential to expand to 750,000 square feet suitable for 2,000 employees. In 2006, the company made another major commitment to Maryland when it decided to site its second manufacturing facility in Frederick, next to its existing plant.

Sources: www.medimmuine.com, www.washingtonpost.com, MdBio, "Bioscience in Maryland 2007," FierceBiotech, "Maryland and the I-270 tech corridor," January 25, 2006.

Service companies. Service companies provide a wide range of support for the research, development and manufacture of therapeutics. Whether through contract research and development, clinical or manufacturing services, these companies represent a key building block in the state's bioscience industry. The category represents approximately one-quarter of the sector's firms and a large share of the state's profitable companies.²⁰

A significant share of biotech service companies are information technology companies specializing in bioscience. The melding of life sciences and computer sciences gained public prominence during the Human Genome Project, which generated staggering amounts of genomic information. Computer science is the only means by which the

¹⁷ *Op. cit.*, MdBio.

¹⁸ There is always uncertainty about the viability of pharmaceutical products under development. One estimate is that 95 percent of drugs fail in development. *Op. cit.*, Economic Alliance of Greater Baltimore.

¹⁹ *Id.*

²⁰ *Op. cit.*, MdBio.

outpouring of such vast amounts of information can be managed and converted from data into knowledge. As interest in human genomics explodes the need for bioinformatics will only grow more critical, and thanks to Celera Genomics and others, Maryland is a global leader in this segment. Below is a brief history regarding one of Maryland's most prominent firms in this segment.

In Vitro Technologies, Inc. (IVT) reflects not only the specialization common within bioscience service companies, but also represents a model of business/economic development. The leading national provider of in vitro testing of chemical-biological interactions, IVT was founded by two doctors in 1990 at the UMBC business incubator, then a group of trailers on the UMBC campus. With critical support from the incubator, IVT managed the transition from promising technology to viable business by using “a strong group of business mentors and advisers” to help them when they were “relatively inexperienced and didn’t know much about business”, this according to Founder, President, and CEO, Paul Silber. The company also took advantage of targeted state resources, winning a Maryland Technology Development Corporation award in 1996. IVT became a key biotech tenant at UMBC, working collaboratively with other UMBC tenants. From its two founders, IVT has grown to 60 technicians and Ph.D.-level scientists in Maryland and now operates a distribution center in Germany.

In 2006, IVT was purchased by London-based Celsis International plc for a reported \$30 million and as much as \$5 million more in earn-out consideration. The inherent qualities of bioscience in Maryland helped land the deal. Silber noted a great location within the Baltimore-Washington area, quality lab space, considerable capacity to expand, and access to BWI for international travel were all important to Celsis.

Source: Sage Policy Group, Inc. and Nearing Group, “UMBC’s Research and Technology Park: Impacts and Opportunities,” November 2006.

Research tools and diagnostics companies. Research tools and diagnostic companies provide the materials needed by researchers and clinicians to conduct biological research, product development, and patient treatment and diagnosis. Firms creating the kits, reagents, instruments, and other supplies and equipment account for roughly 90 of the state’s bioscience companies and 15 percent of its private sector workforce.²¹

Given the specialization common in tools and diagnostics, the typical firm is small with revenues in the \$5 million to \$10 million range. Two international firms with a major presence in Maryland—Invitrogen and Qiagen—are exceptions to this rule with annual revenues of \$1.2 billion and over \$600 million, respectively. These firms are growing in large part through the acquisition of small specialty companies. In 2005 alone, Qiagen acquired eight companies.²²

²¹ *Id.*

²² *Op. cit.*, Economic Alliance of Greater Baltimore.

Atto Biosciences, Inc., now a unit of Becton, Dickinson and Company, represents a case study in how small leading-edge companies can succeed in the marketplace. Specializing in optical instrumentation, software, and reagents for analysis of interactions taking place in living cells, the company's key product is a \$400,000 imaging product used to analyze live cells and biological reactions in three dimensions in real time.

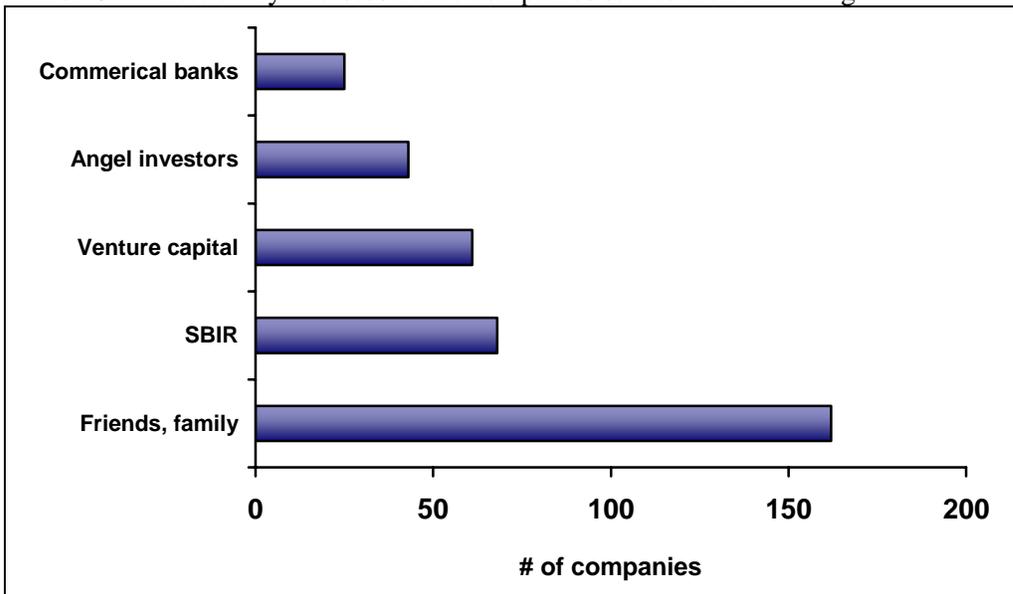
Atto had been privately owned since its inception and was purchased from its founder by Derek Woods in 2001. While successful in raising needed capital, Woods ultimately decided to find a buyer capable of providing the necessary support for long-term success. That buyer was Becton, Dickinson and Company, which purchased Atto in 2004 and integrated it into the larger company as the Bioimaging Systems unit within BD Biosciences, extending BD's capabilities in the high content cell analysis market.

Sources: MdBio, Becton, Dickinson and Company, "BD Announces Acquisition of Atto Bioscience,

Finance

Most commonly, Maryland bioscience companies rely on friends and family for financing. Government programs such as the federal Small Business Innovation Research (SBIR) Program and Maryland Technology Development awards are also common early-stage sources of funds. Exhibit 5 reflects the most common sources of funding for Maryland's bioscience companies.

Exhibit 5: Where Maryland bioscience companies secure their financing



Source: MdBio

Given the long lead times required for FDA approval of pharmaceutical products, many bioscience companies, particularly those developing therapeutic products, are dependent

upon outside financing. As the bioscience sector in Maryland has matured the presence of an array of Maryland-based funding sources has also developed.

Angel investors. Angel investors were once characterized as wealthy individuals willing to write checks to fledgling companies in exchange for a piece of their action. In Maryland today, angel investors are likely to be organized groups of individuals who can critically appraise firms. Such groups like the Chesapeake Emerging Opportunities Club may include successful bioscience entrepreneurs and operate much like venture capitalists as they evaluate investment opportunities.²³

Venture capitalists. Traditional venture capital firms such as Baltimore-based Anthem Capital Management are private firms providing financing and business expertise to startups engaged in health care/life sciences and IT/telecommunications. MedImmune, the most successful of Maryland's bioscience companies, has a wholly-owned subsidiary, MedImmune Ventures, Inc., which operates like a traditional venture capital firm, but restricts its investments to companies with technologies compatible with MedImmune's core mission of treating infectious diseases. The Maryland Venture Fund is an agency of state government initially funded in 1994 by the Maryland legislature. Unlike private sector venture capitalists, the Maryland Venture Funds pursues investment opportunities, but with the stipulation that funds must be invested in Maryland. By 2005, the fund had returned \$55 million on a total investment of \$37 million.²⁴ Between angel investor groups and venture capital agencies, there are 14 such sources of financing based in or with a major presence in Maryland.

For more mature bioscience companies *investment banks* and *hedge funds* represent other substantial financing opportunities. The opportunity for going public with the help of an investment bank or making acquisitions may be a source of additional capital or an exit strategy for a company's founders or leaders. Hedge funds are private investment funds operating in a wide range of financial arenas and are more likely to be engaged in making sizeable investments in bioscience and other types of companies. Given the substantial value of investments typically involved in the work of investment banks and hedge funds, they tend to operate on a national and even international basis.

Whether funding sources are based in Maryland or not, the conventional wisdom seems to be that investment funds seek to invest where money is best treated. If one accepts this to be true, then the investment community must believe that Maryland has great promise. In the 5-year period from 2002 to 2006, the Washington-Baltimore metro area received \$990 million in venture capital, sixth highest in the nation. These investments were made through 144 deals, the fourth highest number of biotechnology venture capital deals in the U.S.²⁵

Even more impressive than the value and number of venture capital deals in this area over that 5-year period was the growth in investment from the previous 5-year period (i.e.

²³ *Op. cit.*, MdBio.

²⁴ *Id.*

²⁵ *Op. cit.*, Economic Alliance of Greater Baltimore.

1997 to 2001). The *number* of venture capital deals in the Washington-Baltimore metro area increased 121.5 percent from the 1997-2001 period to the 2002-2006 period, the best performance in the U.S. and much higher than the second place region, San Francisco, where the number of deals increased a relatively lackluster 37.7 percent. The *value* of venture capital invested in the Washington-Baltimore metro area increased 134.3 percent from the 1997-2001 period to the 2002-2006 period. Again this was the highest increase in the nation and well above the second place area, Boston/New England where the value of venture capital investment increased 90.0 percent.²⁶

This flurry of private investment activity in Maryland is especially welcome given the perception that NIH and other federal funding is less plentiful now and may be even less so in the future. If so, venture capital and other private financing will become even more crucial to the sector's success.

Technology Incubators

Incubators form a critical aspect of the success of Maryland's life sciences industry. The gestation period for success in the biosciences can be lengthy and significant human and physical capital expenses are often involved. MedImmune, featured earlier, required a full decade from its founding to final FDA approval of its blockbuster drug, Synagis, which accounts for well over \$1 billion of the company's \$1.3 billion in annual sales. Moreover, the success of biosciences is almost always the result of melding scientific genius with business acumen, qualities rarely resident in a single individual.

Maryland is home to over 20 business incubators and several additional incubators are in development.²⁷ A number of these concentrate on biosciences and offer support for companies ranging from the newest start-ups to more stable, but still evolving firms. Individual incubators have distinct cultures and services, which implies that in the aggregate the state's incubators can meet the needs of virtually any newly established bioscience company.

In addition to supplying office and lab/wet-lab space (often at subsidized rates), incubators offer general business support to nascent entrepreneurs. Business support ranges from legal, accounting, and financial advice to strategic planning and networking with investors. The State of Maryland through the Technology Development Corporation (TEDCO) actively encourages incubator development and support services with its annual funding programs.²⁸

Beyond support for existing entrepreneurs and start-up companies, Maryland incubators have also taken a proactive stance towards the transfer of technology from the laboratory to the marketplace. The ACTiVATE program at the UMBC incubator, for example, is

²⁶ *Id.*

²⁷ Maryland Technology Development Corporation, "Maryland technology incubators" map, www.marylandtedco.org

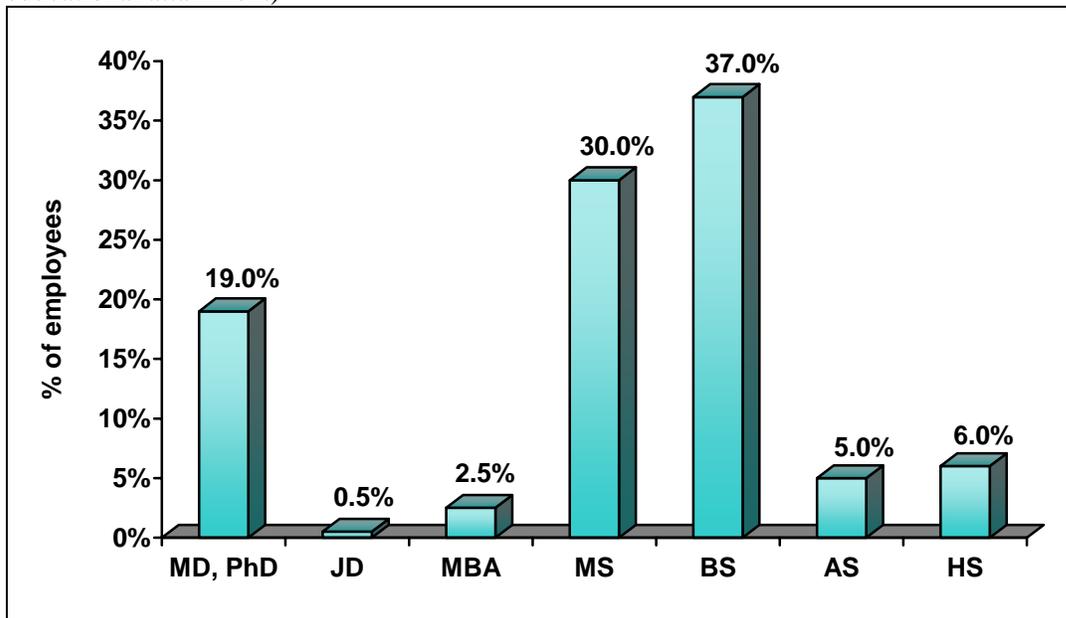
²⁸ TEDCO programs, business incubation, www.marylandtedco.org

directly concerned with the creation of entrepreneurial culture. Each year the program recruits approximately 30 women with an expressed interest in becoming entrepreneurs who form 12 to 15 teams to evaluate and identify commercially viable technologies and then wrap business plans around those innovations to bring relevant technology to market. The technologies selected for analysis are ones developed at UMBC or other Maryland universities. ACTiVATE staff actively screens potentially technologies for viability and engages the creators of the technology (typically faculty members) in the ACTiVATE program. In its first 2 years the program may end up creating six to eight new companies, principally focused upon biosciences and information technology.²⁹

Educators

Because bioscience is an industry that requires continuous innovation and adaptation, it is a sector that requires an unusually specialized, technical and educated workforce. As Exhibit 6 reflects, almost one-fifth of bioscience workers hold doctorates and over half have graduate degrees. An additional 37 percent are college graduates and 5 percent have earned associate degrees.

Exhibit 6: Educational credentials of Maryland bioscience workers (highest level of educational attainment)



Source: MdBio

As Maryland’s bioscience sector expands, the need for well trained laboratory workers and technical staff will rapidly grow. The BioTechnical Institute of Maryland was created in 1998 to train entry-level biotechnicians for industry occupations.³⁰ The state’s higher education sector has also responded to the industry’s emerging needs. Many of course are aware of the specialized training at institutions such as Johns Hopkins, the

²⁹ *Op. cit.*, Sage Policy Group, Inc. and Nearing Group.

³⁰ BioTechnical Institute of Maryland, Laboratory associated program, www.biotechmd.org

University of Maryland, Baltimore, the University of Maryland, College Park and UMBC. However, the response to the bioscience sector's human capital needs has been much broader from an institutional perspective than just these large and leading centers of education. As just one example of the breadth of participation in the educational aspect of Maryland's life sciences sector, Villa Julie now offers three applied science degree programs in biotechnology, medical technology, and forensic science that were developed jointly with industry.³¹

Bioscience Revenue and Impacts

Bioscience is a major source of jobs, income, and gross state product (business sales) in Maryland. It is also an important contributor to State of Maryland coffers through the income and sales taxes generated directly and indirectly by the sector's commercial entities, institutions and employees. The discussion above was intended to provide readers with an understanding of why the study team has included the segments that it has for purposes of economic and fiscal impact estimation.

Methodology

In evaluating the revenue and impacts of the state's bioscience sector, the study team began with the estimate of 30,000 private sector jobs and an additional 30,000 government, academic, and other institutional jobs included in the Governor's press release announcing the formation of the Maryland Life Sciences Advisory Board.³² On the private side, these jobs include those at the therapeutic, services, and tools and diagnostics companies discussed above as well as a relatively small number of other bioscience firms (e.g., those in the fields of agricultural and marine bioscience).

On the institutional side, the study team estimated that roughly 30,000 researchers/workers at institutions such as NIH, FDA, NIST, Walter Reed, Fort Detrick, Johns Hopkins University, the various University of Maryland campuses, other universities and colleges and other institutions that participate directly in the life sciences. This institutional employment estimate is just that—an estimate—of a complex slice of the state economy that comprises workers in many occupational settings and that incorporates some, but not all workers at many organizations.

Estimating impacts begins with an understanding of the expenditures made by entities within Maryland's bioscience sector. These expenditures can be approximated by looking at the revenues that the private sector generates and the operating budgets of public and academic components.

To conduct the analysis, Sage compiled data from various sources. Thankfully, a considerable amount of data exists regarding the biotech industry in the United States as a whole and on biotechnology research and development activities in Maryland. NIH

³¹ *Op. cit.*, Karen Buckelew.

³² Office of the Governor, State of Maryland, "Governor O'Malley announces Maryland Life Sciences Advisory Board," September 14, 2007.

publishes general budget figures and indicates that about 10 percent of their \$28 billion budget supports a staff of 6,000 NIH researchers primarily located on the Rockville campus, or \$466,667 in budget revenues per job. The study team used this figure to calculate the gross economic impacts stemming from NIH's R&D efforts in Maryland. A Fort Detrick press release from 2004 provides analyzable information on a research unit at that facility. This information suggests that budget revenue per job is \$214,156 in 2007 dollars. This figure was also used in estimations of economic impact.

Select data regarding private sector revenue and research budgets are summarized in Exhibit 7. As the exhibit indicates, entities conducting research and development within Maryland's biotechnology sector generated \$193,279 per job according to the 2002 Economic Census.³³ The study team adjusted this number for inflation, bringing the estimate of revenue per job to \$215,201 in 2007 dollars. The study team used the \$215,201 figure in its calculations of the gross economic impacts of bioscience in Maryland.

Exhibit 7: Estimates of bioscience revenues per job, Maryland vs. United States

| NAICS code | Description | Establishments | Receipts (\$000) | Payroll/yr (\$000) | Paid employees | Revenue/job (\$) |
|----------------------|--------------------------|----------------|------------------|--------------------|----------------|------------------|
| Maryland | | | | | | |
| 5417102 | R&D in the life sciences | 320 | 2,065,602 | 823,696 | 11,294 | 182,894 |
| 54171023 | R&D in biotechnology | 147 | 1,031,531 | 466,213 | 5,337 | 193,279 |
| United States | | | | | | |
| 5417102 | R&D in the life sciences | 6,119 | 26,316,797 | 17,418,708 | 244,737 | 107,531 |
| 54171023 | R&D in biotechnology | 2,676 | 12,162,111 | 9,613,005 | 121,931 | 99,746 |

Sources: Economic Census 2002

Using the information above, an estimate of the spending in Maryland per job was developed for the three components of Maryland's bioscience sector as Sage has defined it (private business, NIH, other research institutions). Private sector spending encompasses a wide range of companies from startups operating on shoestring budgets to juggernauts like MedImmune, which generates well over \$400,000 in revenues per job annually. The operating budget for NIH is quite high on a per job basis, reflecting in part the expense required for leading-edge biological research, and most likely the extraordinary expenses required by the nation's leading biological and medical research center. Research expenditures per job at Fort Detrick appear to be more in line with the Economic Census data for biotechnology research in Maryland. As a result, the study team deemed it worth while to segregate NIH research budget spending from the spending of other federal and academic research centers. Total spending by the private sector and Maryland's major research centers is summarized in Exhibit 8. As shown, total spending on an annual basis is estimated at \$15.7 billion, divided almost evenly between private sector revenues and research center operating budgets.

³³ The North American Industrial Classification System defines biotechnology as a subcomponent of the life sciences.

Exhibit 8: Estimates of total bioscience spending in Maryland

| <i>Component of bioscience sector</i> | <i>Jobs</i> | <i>Spending per job</i> | <i>Total spending (millions)</i> |
|---------------------------------------|-------------|-------------------------|----------------------------------|
| Private sector | 30,000 | \$260,000 | \$7,800 |
| NIH | 6,000 | \$450,000 | \$2,700 |
| Other research | 24,000 | \$215,000 | \$5,160 |
| Total/average | 60,000 | \$261,000 | \$15,660 |

Source: Sage Policy Group

These (direct) private sector and research center jobs in Maryland create additional jobs (the multiplier) in two ways. First, in order to operate both private companies and research facilities must purchase goods and services from other businesses, including business in Maryland. These range from exotic requirements such as tissue samples to copy paper. These initial suppliers to the bioscience sector in turn purchase other goods and services from other Maryland businesses. This succession of suppliers and suppliers of suppliers creates economic activity termed the bioscience sector’s indirect effect. Second, workers in the bioscience sector or within the sector’s broader supply chain make consumer/household expenditures that support a wide variety of retail, service and other activities in Maryland. This household-generated impact is termed the sector’s induced effect. Total economic impact, whether measured in dollars or jobs, is the sum of direct, indirect and induced effects.

These indirect and induced impacts can be estimated using econometric software that models Maryland’s economy. Because of the specialized nature of the bioscience sector, Sage modified this software model to more accurately reflect the relationship between the bioscience sector and the state’s economy.³⁴

Economic Impacts

According to the study team’s model, each direct job created by the bioscience sector gives rise to slightly more than one additional job in Maryland. Using estimates of bioscience sector employment issued by the Office of the Governor, it is estimated that roughly 60,000 direct bioscience jobs create an additional 60,341 jobs. This results in a total employment supported estimated exceeding 120,000 jobs in Maryland.

³⁴ Impacts of Maryland’s bioscience sector were estimated using a model developed for this particular analysis. The model was based on software and data from IMPLAN, the industry standard for economic impact assessments of this type. The model was customized using data on the bioscience sector from the Economic Census of 2002 and other sources noted in his report.

Exhibit 9: Estimated job impacts of Maryland bioscience sector

| <i>Component of bioscience sector</i> | <i>Direct</i> | <i>Indirect & induced</i> | <i>Total</i> |
|---------------------------------------|---------------|-------------------------------|--------------|
| Private sector | 30,000 | 30,170 | 60,170 |
| NIH | 6,000 | 6,034 | 12,034 |
| Other research | 24,000 | 24,136 | 48,136 |
| Total/average | 60,000 | 60,341 | 120,341 |

Sources: Office of the Governor, Sage Policy Group

The 120,000 jobs that the bioscience sector supports in Maryland are associated with over \$11 billion in annual income. The sector’s contributions therefore comprise nearly 5 percent of Maryland’s employment and 8.3 percent of wage/salary income. Exhibit 10 provides relevant detail. The average annual income of a worker directly employed in the bioscience sector is estimated at almost \$108,000, not surprising given the elevated levels of education and training required on average to participate in the sector’s activities. As reflected in Exhibit 11, \$29.2 billion in business sales are supported by the industry statewide. This represents 11.3 percent of gross state product, which means that bioscience is responsible for one-ninth of total economic activity in Maryland.

Exhibit 10: Estimated income impacts of Maryland bioscience sector (\$billions)

| <i>Component of bioscience sector</i> | <i>Direct</i> | <i>Indirect & induced</i> | <i>Total</i> |
|---------------------------------------|---------------|-------------------------------|--------------|
| Private sector | \$3.525 | \$2.602 | \$6.127 |
| NIH | \$0.610 | \$0.450 | \$1.060 |
| Other research | \$2.332 | \$1.721 | \$4.053 |
| Total/average | \$6.468 | \$4.774 | \$11.241 |

Source: Sage Policy Group

Exhibit 11: Estimated business sales impacts of Maryland bioscience sector (\$billions)

| <i>Component of bioscience sector</i> | <i>Direct</i> | <i>Indirect & induced</i> | <i>Total</i> |
|---------------------------------------|---------------|-------------------------------|--------------|
| Private sector | \$7.800 | \$7.397 | \$15.197 |
| NIH | \$2.700 | \$1.280 | \$3.980 |
| Other research | \$5.160 | \$4.893 | \$10.053 |
| Total/average | \$15.660 | \$13.570 | \$29.230 |

Source: Sage Policy Group

Fiscal Impacts

The income and sales activity generated by the state’s bioscience sector gives rise to augmented tax revenues for the State of Maryland. Two of the most important sources of tax revenue for the State are the income tax and the sales tax. Corporate taxes are a more modest, but still important, revenue stream for state government. Surveys indicate that two-thirds of the state’s bioscience firms are not profitable, which comes as little surprise since many remain in early formative stages.³⁵ Alternatively, MedImmune and other

³⁵ *Op. cit.*, MdBio.

major corporate entities can and do contribute directly to the state’s coffers through Maryland corporate taxes. To err on the side of conservatism, the estimate of \$17 million in annual corporate tax revenue assumes that bioscience companies contribute at a lower rate than typical Maryland corporations.³⁶

While corporate taxes from the bioscience sector are modest at present, they are likely to grow significantly. Ernst & Young publishes an annual report on the global biotechnology industry. The principal theme of this year’s report is that the industry is clearly heading towards profitability. Indeed, if not for a couple of multibillion-dollar acquisitions that reduced industry revenues and profitability, publicly traded U.S. bioscience firms would have enjoyed their first year of profitability in the industry’s 31-year history.³⁷

Exhibit 12 summarizes estimated annual Maryland income and sales tax receipts from the \$11 billion in income generated by the bioscience sector and corporate taxes on the industry’s \$7.8 billion of revenue. In total, the state receives an estimated \$570 million annually from these taxes.

Exhibit 12: Estimated fiscal impacts of Maryland bioscience sector (\$millions)

| <i>Component of bioscience sector</i> | <i>Income tax</i> | <i>Sales tax</i> | <i>Corporate tax</i> | <i>Total</i> |
|---------------------------------------|-------------------|------------------|----------------------|--------------|
| Private sector | \$196 | \$106 | \$17 | \$319 |
| NIH | \$34 | \$18 | -- | \$52 |
| Other research | \$129 | \$70 | -- | \$199 |
| Total/average | \$359 | \$194 | \$17 | \$570 |

Source: Sage Policy Group

The Bioscience Sector’s Prospects for Expansion

More than virtually any other economic segment, the vibrancy of biosciences depends upon the quality and quantity of human capital. The industry is dependent upon sophisticated people possessing profound knowledge and boundless energy.

It is for this reason as much as any other that prospects for bioscience in Maryland remain so bright. The state/region is arguably home to the nation’s most highly qualified and educated workforce. For instance, in 2005, the Washington-Baltimore metro region led the nation in the share of adults with advanced degrees (18.5 percent), significantly higher than second place Boston (16.3%). That same year, the Washington-Baltimore metro boasted the second highest share of adults with a bachelor’s degree or higher (41%). Only the San Francisco-San Jose metropolitan area reported a larger share (41.1%).

³⁶ Corporate taxes can be estimated on the basis of the ratio of such taxes to income or sales taxes. On that basis bioscience companies would be expected to generate over \$25 million in corporate taxes for the State of Maryland. Because of the prevalence of unprofitable, smaller bioscience companies, Sage’s estimate is two-thirds of this number or \$17 million.

³⁷ Ernst & Young, “Beyond Borders: Global Biotechnology Report 2007,” 2007.

These highly educated, specially trained people are positioned to produce the foundation of industry expansion: intellectual property. A survey undertaken by the Association of University Technology Managers (AUTM) found that in the past 10 years, research support for the nation's universities, hospitals and research institutions provided by federal government and industry sources more than doubled, increasing from \$21.6 billion in 1997 to \$45.4 billion in 2006.³⁸ Not coincidentally, over the past decade, the number of invention disclosures has risen every year from 10,613 in 1997 to 18,874 in 2006. Patent applications from universities, hospitals and research institutions have also been increasing in recent years. The number of new patent applications filed increased from 6,397 in 2001 to 11,622 in 2006.

As noted earlier in this report, Johns Hopkins University remains one of the nation's premier research universities. According to the AUTM survey, JHU generated research expenditures of \$1.8 billion in 2006. This total includes NIH research monies, but clearly encompasses funding from other sources. Only the University of California System with 10 individual campuses throughout California received more research monies that year (\$3.0 billion). But among individual institutions, JHU is unrivaled in its ability to capture research funds.³⁹

JHU's capacity to convert research into intellectual property and commercially viable products and services is less apparent. The University recently ranked third in the world in biotechnology patents and seventh in biotechnology publications despite its industry leading research and development budget. More tellingly, JHU ranked 37th in university tech transfer and commercialization while MIT, the University of California System, Cal Tech, and Stanford—located in the hearts of the nation's leading biotechnology centers, California and Massachusetts—ranked first through fourth.⁴⁰

Over the past decade or more, JHU has significantly enhanced its technology transfer efforts. The University recently hired the former head of Maryland's economic development agency to be its tech transfer and commercialization czar. The position reports directly to the President. A number of highly visible and successful startups were established with or supported by technologies developed at JHU, including Avigen, Inc., BioFortis, Guilford Pharmaceuticals, Inc. and Xencor.

Indeed, the clearest sign of bioscience's future in Maryland may be the development of two biotechnology parks in Baltimore City, flanking downtown to its east and west and physically linking Maryland's two dominant research universities (JHU and UMB) with the heart of the local commercial sector. These are massive developments in their own right and will produce in excess of \$1 billion in construction. Development will extend well into the next decade. The realization of the promise held in these two parks would constitute a quantum leap in the development of Maryland's bioscience industry, clearly placing it in the first tier of bioscience centers in the nation and in the world.

³⁸ AUTM, "U.S. Licensing activity survey, FY 2006: a survey of technology licensing (and related) activity for U.S. academic and nonprofit institutions and technology investment firms," www.autm.org.

³⁹ *Id.*

⁴⁰ *Op. cit.*, Economic Alliance of Greater Baltimore.

Conclusion

Maryland's bioscience sector is among the nation's largest, if not the largest, generating \$29 billion in annual economic output, \$11 billion in income and nearly \$600 million in State government taxes. The average job supported directly by the state's life sciences industry pays \$108,000/annum. Almost one-fifth of bioscience workers hold doctorates and over half have graduate degrees.

The global investment community has taken notice of Maryland's enormous potential for commercialization and profitability. Conventional wisdom holds that investment funds invest where money is best treated. Based on this, it is clear that investors believe Maryland holds great promise. In the 5-year period from 2002 to 2006, the Washington-Baltimore metro area received \$990 million in life sciences-targeted venture capital, sixth highest in the nation. These investments were made through 144 deals, the fourth highest number of biotechnology venture capital deals in the U.S.⁴¹

Even more impressive than the value and number of venture capital deals in this area over that 5-year period was the growth in investment from the previous 5-year period (i.e. 1997 to 2001). The *number* of life-science oriented venture capital deals in the Washington-Baltimore metro area increased 121.5 percent from the 1997-2001 period to the 2002-2006 period, the best performance in the U.S. and much higher than the second place region, San Francisco, where the number of deals increased a relatively lackluster 37.7 percent. The *value* of life-science oriented venture capital invested in the Washington-Baltimore metro area increased 134.3 percent from the 1997-2001 period to the 2002-2006 period. Again this was the highest increase in the nation and well above the second place area, Boston/New England where the value of venture capital investment increased 90.0 percent.⁴²

Over the next decade, Maryland's biotech sector is poised to become even more globally pre-eminent. The development of two biotechnology parks in Baltimore City in conjunction with the massive and expanding life sciences cluster in Maryland's D.C. Suburbs may be enough to push Maryland past Massachusetts and California assuming that Maryland isn't already number one. Indeed, given its vast institutional presence (e.g., NIH, FDA, JHU, NIST, Fort Detrick, UMB, UMBI), Maryland may already be number one in terms of the size of its broadly defined bioscience sector. One would have to study only California and Massachusetts to confirm this.

Policymakers could do much to improve Maryland's competitive profile and biotech business environment. For instance, Maryland can and should follow the lead of other states that allocate a higher percentage of State pension fund dollars toward investment in technology industries. The State could also add tax incentive programs to encourage private sector investment and increase funding (dramatically, e.g., 70 percent) for its seed funding programs – TEDCO, DBED's Maryland Venture Fund and UMCP's MIPS program.

⁴¹ *Op. cit.*, Economic Alliance of Greater Baltimore.

⁴² *Id.*

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