ACCELERATING UTAH'S LIFE SCIENCES INDUSTRY

Utah Cluster Acceleration Partnership Summer 2012

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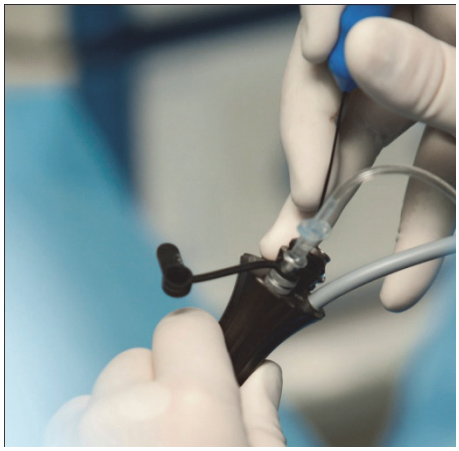


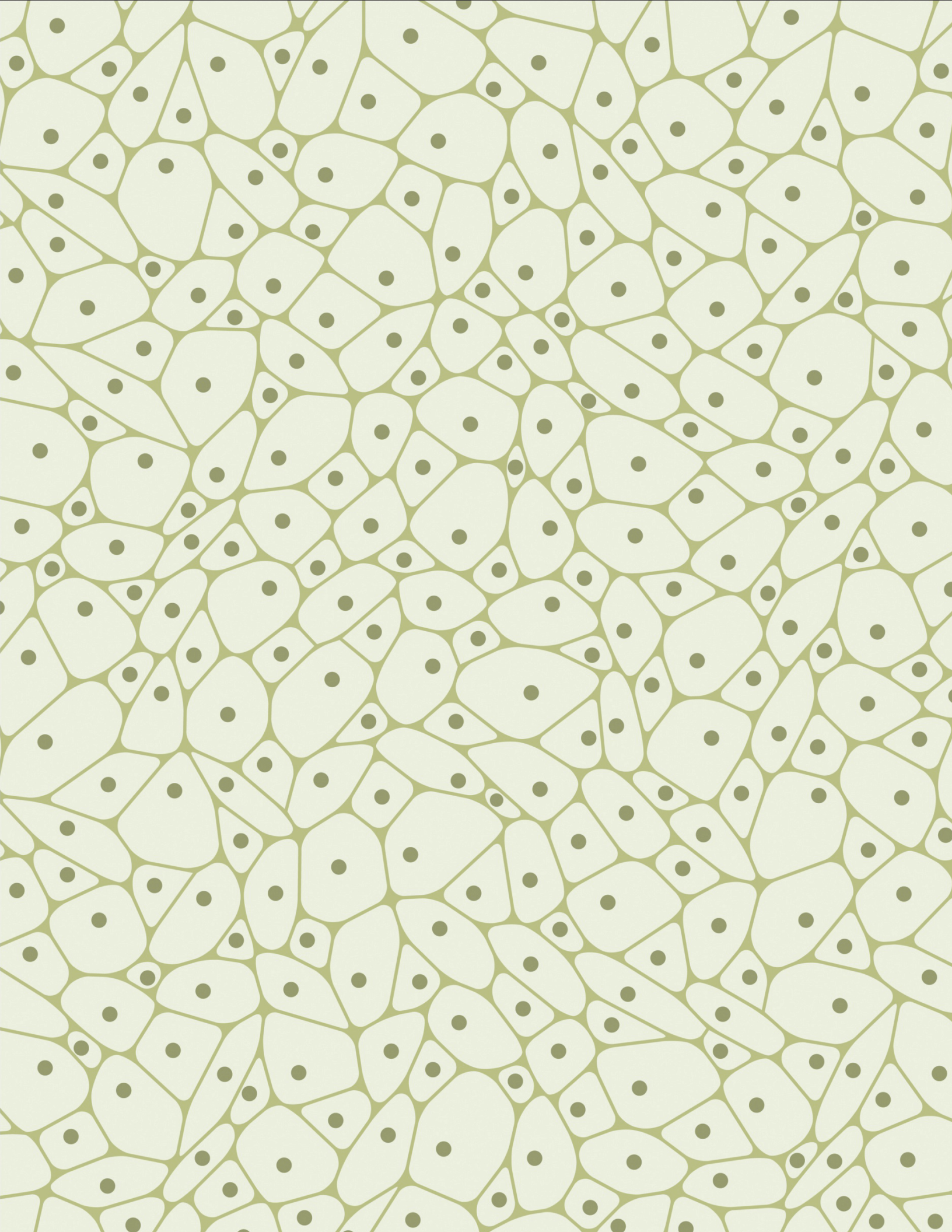
This report presents specific strategies designed to accelerate and support the growth and expansion of Utah's life sciences industry and to ensure that Utah develops and maintains the talent needed to sustain continued growth of this industry.

This strategy was developed with guidance and input from a project steering committee and a strategic review committee that included representatives of Utah's life-science companies, research universities, community colleges, state government, and business and economic development organizations. Every effort was made to obtain inputs in as many ways as possible from the state's life sciences community, including one-on-one interviews, surveys, and focus group discussions.

This Utah Cluster Acceleration Partnership project is sponsored by the Utah System of Higher Education, the Utah Department of Workforce Services, and the Utah Governor's Office of Economic Development. Westminster College along with the University of Utah serves as the convening institutions.

The Battelle Technology Partnership Practice (TPP) was engaged to analyze Utah's life sciences industry sector and research and development base, identify any gaps in the state's life-science infrastructure, and facilitate the development of strategies and actions. TPP is the consulting arm of Battelle, the world's largest, nonprofit independent research and development organization. For more information on TPP, please contact Mitch Horowitz, Vice President and Managing Director, at horowitzm@battelle.org.

For more information on this and other Utah Cluster Acceleration Partnership projects, please contact the Utah System of Higher Education.



Executive Summary

This report is based on findings derived from extensive inputs from industry, university and broader education, and economic development leadership in the life sciences, and a detailed quantitative assessment of the life sciences industry in Utah, focusing on core technology and broader talent, innovation and research position of the state. It provides a Life Sciences Cluster Acceleration Strategy, setting out a detailed plan of action to guide this fast growing industry in Utah.

The major findings of the assessment are summarized below.

- **Utah's life sciences industry grew rapidly from 2001 to 2010, outpacing a growing national sector.** Employment in Utah's life sciences industry grew by 25.8 percent from 2001 to 2010, which included a 9.2 percent increase in jobs from 2007 through 2010, the period from the economic peak in 2007 through the recession years and the first full year of the recovery (2010). At the national level, growth in life sciences employment was 8.4 percent from 2001 to 2010, but essentially flat during the period 2007 through 2010.
- **Utah is specialized in its industry concentration compared to the nation and outpacing national growth in all four life sciences industry subsectors.** A comparison of the life sciences industry in Utah to that of the nation using standard national industry classifications reveals that across four major subsectors—Medical Devices and Equipment; Drugs and Pharmaceuticals; Research, Testing, and Medical Labs; and Biomedical Distribution—Utah is specialized with at least 20 percent higher level of industry concentration than is found at the national level for that subsector. In addition, each of the major subsectors of the life sciences industry is growing faster in Utah.[1]
- **Utah's life sciences industry is a source of high-wage jobs, paying average annual wages that are more than 50 percent greater than that for the overall private sector.** The average wage for jobs in the life sciences stands at $59,480, 53 percent above the private sector average of $38,932.
- **The life sciences industry has a significant impact on the Utah economy.** In 2010 the Utah life sciences industry cluster contributed $14.6 billion in economic output to the state, supported more than 63,000 jobs with workers earning $3.5 billion in personal income (includes direct, indirect, and induced impacts).

[1] It is important to note that natural products and dietary supplements companies do not have a stand-alone industry classification in the standard industry classification system, and are typically found within the Drugs and Pharmaceuticals and Biomedical Wholesale Trade subsectors.

- **Line of sight analysis of core competencies to market opportunities suggests many opportunities in Utah for growth in the life sciences industry cluster in the years ahead.** A detailed quantitative and qualitative analysis by Battelle led to the identification of 17 life-science core competencies in Utah based on analyses of patents, publications, major research centers, detailed industry strengths, venture-backed companies, and insights gained from more than 70 interviews with key researchers and administrators from Utah universities and industry CEOs. Matching life sciences research strengths with Utah's existing industry strengths suggests four areas that appear to offer the best opportunity for growth in Utah's life sciences industry cluster:
    - Novel medical devices
    - Molecular diagnostics and personalized medicine
    - Molecular medicine; drug discovery, development, and delivery
    - Natural products and dietary supplements.

It is clear from the qualitative analysis noted above that Utah has a strong base on which to continue to build its life sciences industry cluster. However, to realize the opportunities in the areas suggested above, Utah will need to maintain a competitive position in the life sciences and address any gaps in its life-science infrastructure. To be a leader in the life sciences, Utah must ensure that the state has:

- A robust life-science R&D infrastructure committed to engaging with locally-based life-science companies and facilitating commercialization of life-science discoveries
- A significant pool of talent in life sciences disciplines
- Capital markets able to support life-science companies through all stages of development
- A supportive business climate.

Results of a detailed quantitative assessment of life-science performance indicators across these key growth factors, along with findings generated from more than 70 interviews with CEOs of life science companies, life science entrepreneurs, bioscience companies, bioscience entrepreneurs, university leaders, university tech transfer staffs, economic development organizations, community college staff, and representatives of the venture capital community, indicate that in order to significantly accelerate the growth of Utah's life sciences industry cluster, the following four issues must be addressed.

1. **Utah must put in place a comprehensive approach to advancing talent development in life sciences disciplines.** This effort must work at each level of the talent pipeline from K–12 to post-secondary education to workforce development; it must create linkages across the life sciences industry cluster through promotion of activities associated with science, technology, engineering, and math ("STEM") education; career pathways; internships; and employer-guided curriculum and certificates, among other actions.

2. **Actions must be undertaken to address the capital needs of life-science companies.** This need extends across all stages of life-science firm development from proof-of-concept to seed funding to more formal rounds of venture capital investment.
3. **Utah should better leverage its university research base by encouraging and facilitating industry/university collaboration.** Such collaboration is needed not only to move research discoveries into the marketplace, but also to help Utah's life-science companies move up the value chain so that they are producing higher value-added products and services.
4. **Utah should undertake an advocacy campaign to promote the state as a center for the life sciences and to take a leadership role on federal policy reform.** These efforts need to raise the profile of Utah in the life sciences industry by making the state a destination for life-science business executives as well as address the image of Utah as a diverse and welcoming place. The success of these efforts depends upon having the resources in place to leverage the growing presence of life sciences in Utah. There is also a large need to engage, as a state, in the national policy debates surrounding FDA regulatory reform. Utah Technology Council is well positioned to lead the effort to join forces with other states in the national policy debates surrounding federal regulatory reform. Without a dedicated effort to monitor and help influence national policy and align state efforts, Utah will remain a silent voice.

Across these four strategic priorities to accelerate the growth of Utah's life sciences industry cluster, 17 specific actions were identified as set out in the chart below:

Develop, Retain and Attract Bioscience Talent	• Engage industry to identify specific education and training needs and provide input to develop and enhance curricula • Develop and implement life sciences career pathways • Expand outreach programs to inform and encourage students to consider careers in the life sciences • Promote and fund efforts to improve STEM education • Develop and implement a C-level talent attraction initiative • Grow the number of post-secondary internships in the life sciences
Ensure Access to Capital at All Stages of Firm Development	• Support commercialization and proof-of-concept projects • Promote the availablility of venture capital for life sciences industry in Utah across all stages of venture investment • Sustain the Life Science Tax Credit
Significantly Increase University/Industry Collaborations	• Foster greater industry and university collaboration in applied research • Promote the economic development mission of university technology transfer and commercialization • Foster greater industry and university interactions and partnering
Advocate for Utah's Life Science Industry	• Continue efforts to attract national and international life science conferences to Utah and maintain Utah's presence at key national life sciences conferences held outside of the state • Continue efforts to project an image of Utah as a diverse and welcoming state • Promote active outreach marketing of Utah in the life sciences • Ensure the capacity within state government to advance the interests and address the needs of the life sciences • Advocate for Utah's life sciences industry

Letter of Conveyance

As members of the Life Sciences Acceleration Strategy and Steering Committees, we express our support for the recommended actions and strategies that are outlined in this report.

Utah's life sciences industry employs nearly 23,000 workers and produced $9.6 billion in economic output in 2010. This diverse industry, with strengths in medical devices, research and testing, pharmaceuticals, and natural products and dietary supplements, has been and continues to be a key driver of Utah's economy. Employment in Utah's life sciences industry grew 26 percent between 2001 and 2010, including continued job growth during the recent recession. This has well outpaced overall Utah private sector industry growth. And the average wages for jobs in the life sciences stands at $59,480, well above the private sector average of $38,932.

In light of the importance of the life sciences industry cluster to Utah's economy, it is critical to ensure its continued growth and development as part of the Governor's goal to accelerate job growth in Utah.

Members of the Life Sciences Cluster Acceleration Strategy Steering Committee

University of Utah – Co-convening Institution

Westminster College – Co-convening Institution

Special recognition and appreciation to Westminster College and the University of Utah for their support of this effort.

UCAP Oversight Committee

Spencer Eccles, Executive Director, Governor's Office of Economic Development

Kristen Cox, Executive Director, Department of Workforce Services

William Sederburg, Commissioner of Higher Education, Utah System of Higher Education

Life Sciences Industry

Jeff Nelson, Nelson Labs, Chair

Lawrence Hill, Watson Labs

Andrew Laver, PPL Capital Advisors

Richard Nelson, Utah Technology Council

Pratap Khanwilkar, Ignition Key

Judy Young, Utah Technology Council

Public Sector

Beth Colosimo, Economic Development Corporation of Utah

Tami Goetz, Governor's Office of Economic Development

Ted McAleer, USTAR

Lynn Purdin, Department of Workforce Services

Rachael Stewart, Department of Workforce Services

Suzanne Winters, USTAR

Education

Tom Parks, University of Utah

Michael Basis, Westminster College

Cameron Martin, Utah System of Higher Education

Jeff Aird, Utah System of Higher Education

David Clark, Utah State University (former life science CEO)

Ned Weinshenker, Utah State University (former life science CEO)

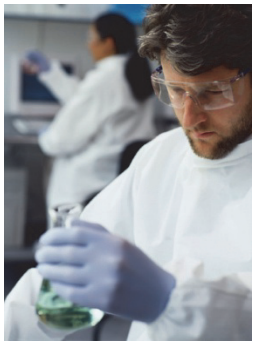
Lynn Heinlein, Westminster College

Michael Keene, Westminster College

Battelle Project Team Leaders

Marianne Clarke

Mitchell Horowitz



Utah Life Sciences Industry Cluster Acceleration Strategy Review Committee

In addition to the steering committee, the following leaders provided critical insight to the final set of strategies and actions included in this strategy.

Dennis Briscoe, Wescor

Craig Caldwell, Salt Lake Community College

Mary Jane Chase, Westminster College

Skip Domenick, Aplion Medical

Jeff Edwards, Economic Development Corporation of Utah

Mike Feldman, Wasatch Breakthrough

Ping Fong, Biomedical Management Resources

Ashok Khandkar, BloXr Corp.

Richard Koehn, SentrX Animal Care, Inc.

Robert Lippert, Serial Entrepreneur (former President and CEO of Zars Inc.)

Rick Mandahl, UNIconnect

Tim Miller, Echelon Biosciences

Michael Paul, Lineagen, Inc.

Kirk Ririe, Idaho Technologies

Tamee Roberts, Utah Fund of Funds

Florian Salzbacher, University of Utah

Clifton Sanders, Salt Lake Community College

Janice Sugiyama, Utah Valley University

Tom Thatcher, Thatcher Pharmaceutical

Kimball Thomson, MD4

D. Clark Turner, Aribex

Cindy Walters, Haemonetics

Layne Webb, Edwards Lifesciences

Walt Murray, Master Control

Introduction

The Utah Cluster Acceleration Partnership (UCAP) is an initiative focused on increasing the economic impact of Utah's critical industry clusters and the contribution made by the various institutions of higher education.

Utah's higher education institutions are strong drivers of economic development. In addition to educating a highly-skilled workforce, they conduct world-class research and development (R&D) that often leads to new discoveries that can be developed into new products and even whole new industries. The Utah Cluster Acceleration Partnership, a collaborative effort of the Utah Department of Workforce Services (DWS), the Utah System of Higher Education (USHE), and the Governor's Office of Economic Development (GOED), was created to find ways to best leverage Utah's universities and colleges to help grow the state's leading industry clusters.

This acceleration strategy focuses on Utah's life sciences industry cluster, and recommends a set of actions to accelerate the sector's growth. It was developed under the leadership of the University of Utah and Westminster College, with technical support provided by Battelle's Technology Partnership Practice. Substantial guidance and input was also provided from a project steering committee that included representatives from USHE and its member colleges and universities; Utah life sciences industry executives and the life-science industry's trade association Utah Technology Council; state government; and economic and workforce development organizations.

Every effort was made to obtain inputs in as many ways as possible from the state's life sciences community, with close coordination with the Utah Technology Council, colleges and universities, and state government officials. Battelle conducted approximately 70 interviews and presented the input from the interviews along with findings from various analyses at the MD4 Utah Summit[2] that was held in October 2011. The project steering committee met three times to review findings and develop a proposed set of strategies and actions. In addition, a life sciences industry cluster acceleration strategy review committee composed of Utah's life sciences industry leaders reviewed preliminary recommendations and provided input incorporated in this document.

The Battelle project team collected and analyzed data on Utah's life sciences research and industry base; assessed the state's competitive position in life sciences development; and interviewed academic, research, business, and civic leaders to develop an understanding of Utah's existing life sciences research strengths and

[2] For more information see the MD4 website at http://md4utah.org/about-us

capabilities and to gather input on the types of investments that need to be made to enable Utah's life sciences industry cluster to be a key driver of Utah's future economy.

This report

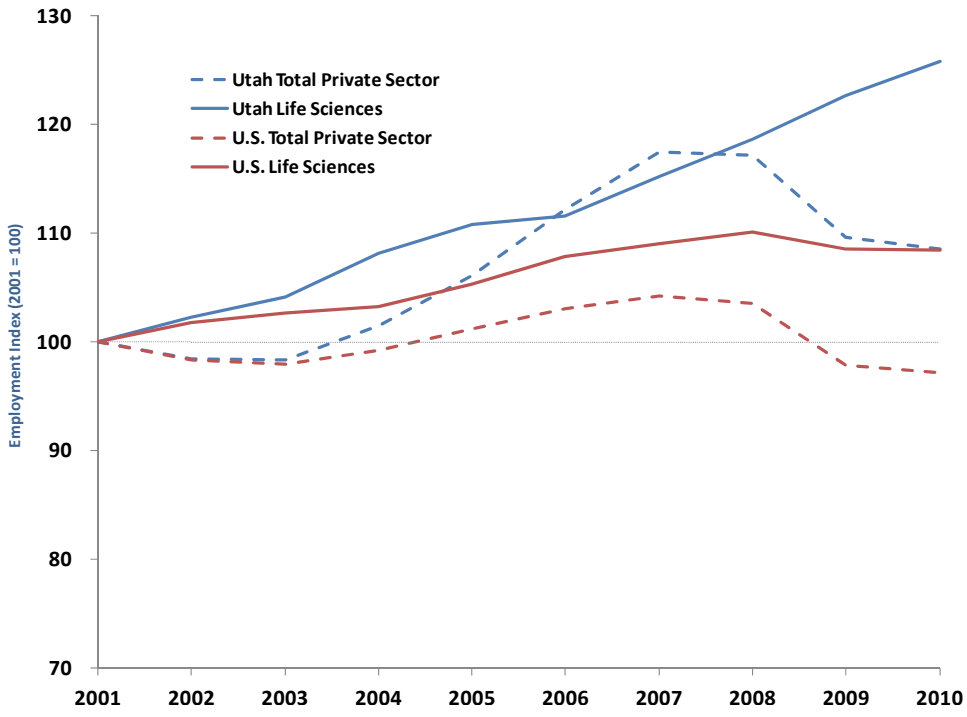
- Examines Utah's life sciences industry cluster and its contributions to Utah's economy;
- Assesses Utah's life-science R&D base and identifies specific technology areas that appear to offer the greatest opportunity for growth in Utah;
- Reviews Utah's competitive position in the life sciences and identifies gaps in policies and programs that need to be addressed if Utah is to continue to grow its life sciences industry cluster;
- Presents a set of strategies and actions for addressing gaps and capitalizing on opportunities; and
- Outlines an implementation plan to promote and sustain growth in Utah's life sciences industry cluster.

Utah's Life Sciences Industry Cluster

Utah's life sciences industry cluster is vibrant and growing rapidly.

Utah's life sciences industry grew rapidly from 2001 to 2010, outpacing a fast-growing national sector. As set out in Figure 1, Utah's life sciences industry, using standard national industry classifications, is defined as including four major subsectors—Medical Devices and Equipment; Drugs and Pharmaceuticals; Research, Testing, and Medical Labs; and Biomedical Distribution employed 22,983 workers in 2010. Natural products and dietary supplement companies, which do not have a stand-alone industry classification in the standard national industry classification system, are found across these subsectors, especially Drugs and Pharmaceuticals and Biomedical Distribution.

Figure 1: Utah Life-Science Employment Trends, 2001–2010



Employment in Utah's life sciences industry grew by 25.8 percent from 2001 to 2010. This includes a 9.2 percent increase in jobs from 2007 through 2010, the period from the economic peak in 2007 through the recession years and the first full year of the recovery (2010). At the national level, life-science employment grew by 8.4 percent from 2001 to 2010 and was essentially flat over the recent 3-year period (-0.5 percent).

Utah has experienced rapid, significant job growth across all four major life sciences subsectors over the decade. Employment growth was driven by a 61 percent increase in employment in Research, Testing, and Medical Labs and a 47 percent increase in Biomedical Distribution since 2001. Utah's Drugs and Pharmaceutical subsector grew an impressive 23 percent, given that this sector contracted by 0.7 percent nationally. Employment in the Medical Device and Equipment subsector grew more slowly at nearly 6 percent, but grew nonetheless while the national device subsector was flat.

Utah has a specialization in all four life sciences subsectors, based on the state's concentration of employment being at least 20 percent higher than is found at the national level for that subsector.[1] Utah's medical device industry is nearly three times as concentrated as the U.S. See Table 1.

Table 1: Utah Life Sciences Industry, Summary Employment Position and Recent Trends, 2010

Life Science Industry & Major Subsectors	UT Employment, 2010	UT Location Quotient, 2010	Employment Change, 2001-07 (Previous Business Cycle)		Employment Change, 2007-10 (Current Business Cycle)		Employment Change, 2001-10 (Full Period)	
			Utah	U.S.	Utah	U.S.	Utah	U.S.
Total Life Sciences	**22,983**	**1.82**	**15.2%**	**9.0%**	**9.2%**	**-0.5%**	**25.8%**	**8.4%**
Medical Devices & Equipment	8,741	2.97	0.1%	-0.1%	5.4%	0.1%	5.5%	0.0%
Research, Testing, & Medical Labs	5,857	1.43	28.4%	15.4%	25.1%	6.1%	60.7%	22.5%
Drugs & Pharmaceuticals	4,702	1.89	19.3%	5.0%	3.0%	-5.4%	22.9%	-0.7%
Biomedical Distribution	3,683	1.19	39.4%	14.4%	5.1%	-5.1%	46.5%	8.6%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

Utah's life sciences industry is a source of high-wage jobs paying average annual wages more than 50 percent greater compared to the overall private sector. The average annual wage of a Utah worker employed by a life-science company was $59,480 in 2010, compared to an annual average wage of about $39,000 for the overall private sector. It is also the case, however, that life sciences industry wages are lower in Utah than nationally. The average wage of life-science employees at the national level was approximately $86,000, almost $27,000 higher than in Utah. This may be due, in part, to the fact that Utah's biomedical industry has a lower value added per worker ($106,379) than is found nationally ($120,313). Value added is the difference in output less the costs of inputs. It should be noted that all of Utah's technology-based industry clusters have a lower value added than their industry has at the national level. A lower value added suggests that Utah's companies are not focused on more complex, higher-value products. This also suggests that there is an opportunity for Utah to help its companies move up the value chain and to focus on attracting higher value-added operations.

Table 2: Average Annual Wages, Utah and U.S., 2010

Industry	Avg. Annual Wages		UT Share of U.S. Avg.
	UT 2010	U.S. 2010	
Management of Companies and Enterprises	$ 78,043	$ 98,215	79%
Biomedical Distribution	**$ 76,902**	**$ 88,191**	**87%**
Mining, Quarrying, and Oil and Gas Extraction	$ 70,053	$ 90,397	77%
Professional, Scientific, and Technical Services	$ 59,691	$ 77,313	77%
Total Life Sciences	**$ 59,480**	**$ 86,211**	**69%**
Research, Testing, & Medical Laboratories	**$ 57,142**	**$ 84,305**	**68%**
Medical Devices & Equipment	**$ 55,744**	**$ 73,591**	**76%**
Drugs & Pharmaceuticals	**$ 55,694**	**$ 101,830**	**55%**
Wholesale Trade	$ 54,489	$ 63,628	86%
Finance and Insurance	$ 54,145	$ 84,516	64%
Information	$ 52,447	$ 74,382	71%
Manufacturing	$ 49,491	$ 57,511	86%
Construction	$ 42,077	$ 49,588	85%
Transportation and Warehousing	$ 40,982	$ 44,198	93%
Total Private Sector	**$ 38,932**	**$ 46,451**	**84%**
Health Care and Social Assistance	$ 37,556	$ 43,732	86%
Agriculture, Forestry, Fishing and Hunting	$ 27,110	$ 26,626	102%
Retail Trade	$ 25,982	$ 26,655	97%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

A number of specific life sciences industries in Utah are both specialized and growing. They include:

- Pharmaceutical Preparation Manufacturing
- Medical Laboratories
- Drugs Wholesalers
- Irradiation Apparatus Manufacturing
- Medicinal and Botanical Manufacturing
- Dental Equipment and Supplies Manufacturing.

Industries that are growing but in which Utah is not yet specialized include: Life Sciences Commercial Research and Development; Medical, Dental, and Hospital Equipment and Supplies Wholesalers; Surgical Appliance and Supplies Manufacturing; Electromedical and Electrotherapeutic Apparatus Manufacturing; and Analytical Lab Instrument Manufacturing.

Economic Impact of Utah's Life Sciences Industry Cluster

The Utah life sciences industry cluster has a large economic footprint in the state and is a key contributor to the economy. The cluster had estimated revenues of $9.6 billion[2] and employed 22,983 workers earning an estimated $1.8 billion in personal income in 2010 (see Table 3). The cluster generated an additional $2.8 billion in output through *Indirect Impacts*—its purchases of goods and services from other companies and organizations in the region, and $2.1 billion in output through *Induced Impacts*—local spending by Utah residents employed in or impacted by the sector.

Taken all together, in 2010 the Utah life sciences industry cluster contributed $14.6 billion in economic output to the state, supported more than 63,000 jobs with workers earning $3.5 billion in personal income (includes direct, indirect, and induced impacts). Every job created in Utah's life sciences sector created an additional 2.77 jobs in the economy.

Table 3: Economic Impacts of the Utah Life Sciences Industry Cluster, 2010 ($ in Millions)

Impact Type	Employment	Personal Income	Value Added	Output
Direct Effect	22,983	$1,762	$2,976	$9,612
Indirect Impacts	21,078	$1,033	$1,558	$2,831
Induced Impacts	19,532	$671	$1,250	$2,131
Total Impact	**63,592**	**$3,467**	**$5,785**	**$14,574**
Impact Multiplier	2.77	1.97	1.94	1.52

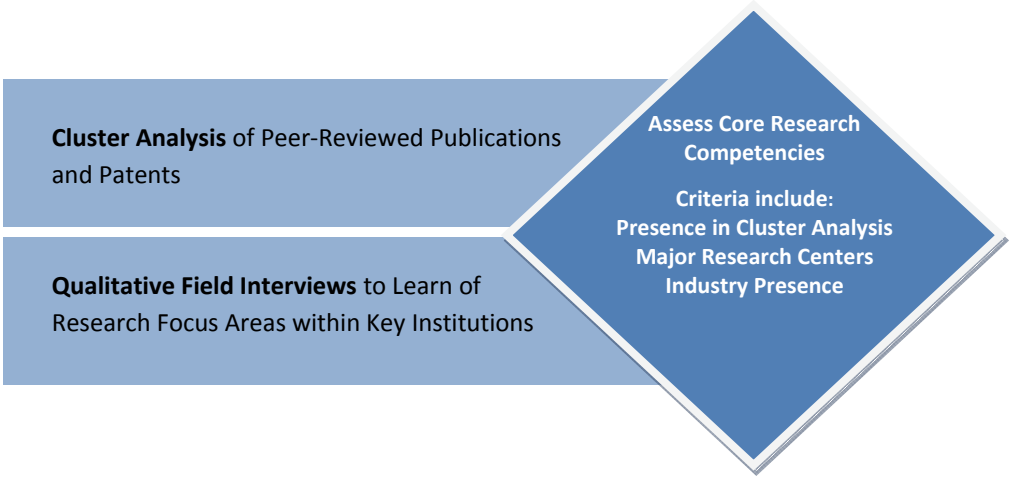
Source: Battelle analysis of Utah IMPLAN Input/Output model.

Utah's Life Sciences Opportunity Areas

As life sciences research leads to more and more discoveries that offer opportunities for market applications, increasing numbers of regions, states, and countries are targeting the life sciences as a potential growth sector. The key to succeeding in life sciences development lies in identifying, within the overall life sciences industry cluster, targeted strategic areas in which a state has comparative advantages on which to build. A key factor in determining these comparative advantages is to identify the core competencies found in a state's industry and university base. Research core competencies are those fields with a critical mass of ongoing activity along with some measure of excellence. No single source of information is sufficient to identify research core competencies. Rather, various integrated and complementary analyses are required to identify areas of focus that may contribute or lead to a state's future growth in the life sciences.

Using both quantitative and qualitative methods, Battelle has developed a methodology for assessing the core competencies of research institutions and industry (Figure 2). Battelle's quantitative assessment involves a unique cluster analysis of publications and patents that was used to identify Utah's life-science core competencies. Battelle identified 17 life-science core competencies in Utah based on analyses of patents, publications, presence of major research centers, presence of industry strength, and presence of venture-

Figure 2: Process for Core Competency Identification



backed companies and insights gained from more than 70 interviews with key researchers and administrators from Utah universities and industry CEOs.

Utah's 17 life-science core competencies can be grouped into four major innovation themes:

- Medical Devices
- Disease Research and Pharmaceuticals
- Basic Biotechnology Research
- Natural Products.

Matching these areas of life-science research strengths with Utah's existing industry strengths suggests four areas that appear to offer the best opportunity for growing Utah's life sciences industry cluster. (See Figure 3) They are:

- Novel medical devices
- Molecular diagnostics and personalized medicine
- Molecular medicine; drug discovery, development and delivery
- Natural products and dietary supplements.

Figure 3: Line of Sight from Innovation Themes to Detailed Industry Strengths to Possible Growth Opportunities for the Future

Innovation Themes	Detailed Industry Strengths	Possible Growth Opportunities for the Future
LIFE SCIENCE		
Medical Device Disease Research, Drugs and Pharmaceutical Basic Biological Research Natural Products	▪ Pharmaceutical Preparation Manufacturing ▪ Medical Laboratories ▪ Drugs Wholesalers ▪ Irradiation Apparatus Manufacturing ▪ Dental Laboratories ▪ Medicinal and Botanical Manufacturing ▪ Electromedical and Electrotherapeutic Apparatus Manufacturing ▪ Life science Commercial Research & Development ▪ Medical, Dental and Hospital Equipment & Supplies Wholesalers ▪ Surgical Appliance and Supplies Manufacturing ▪ Surgical and Medical Instrument Manufacturing ▪ Dental Equipment and Supplies Manufacturing	Novel medical devices Molecular diagnostics and personalized medicine Molecular medicine, drug discovery, development and delivery Natural products and dietary supplements

Each technology area is discussed below.

Novel Medical Devices

A medical device is a product involved in diagnosis, therapy, or surgery for medical purposes. It involves a wide range of products from imaging to monitoring to implants to surgical instruments and equipment. A major revolution is taking place in advanced medical devices involving the introduction of advanced technologies to improve tools for diagnosis and treatment and the development of biological substitutes to restore, maintain, and improve tissue, bone, and organ condition. Some of the leading technologies being adapted for use in innovative medical treatments and diagnostics include microelectronics, imaging, nanotechnology-related biosensors, robotics, and biopolymer materials.

HOW IT BUILDS ON UTAH STRENGTHS

Utah has a broad medical device industry including strong specializations in Surgical and Medical Instruments, Dental Equipment, and Irradiation Apparatus, and emerging strengths with growing employment in Electromedical and Electrotherapeutic Devices, and Surgical Appliance and Supplies Manufacturing. Utah is home to a growing number of global medical device companies including

- Bard Access Systems, a division of CR Bard located in Salt Lake City, a market leader in vascular access devices
- BD Medical, a global medical technology company that manufactures medical supplies, devices, lab equipment, and diagnostics products.
- Edwards Life Science, a global leader in the science of heart valves and hemodynamic monitoring.
- Merit Medical Systems, founded in 1987, a worldwide company engaged in the development, manufacture, and distribution of proprietary disposable medical devices.

Utah also has a number of emerging medical device companies. Among the firms that received venture financing between 2006 and the first quarter of 2011 were:

- Amedica Corporation, for developing orthopedic devices
- Catheter Connections, Inc., for developing medical infusion accessory products
- Coherex Medical, for developing medical devices for addressing structural heart diseases
- Control Medical Technology, for developing aspirator devices where fluids are aspired through small devices
- Health Line International, for developing vascular access and infusion therapy products
- Vital Access Corporation, for developing surgical and interventional technologies for vascular access
- White Pine Medical, with a focus on cardiovascular, orthopedics and neurostimulation devices
- WorldHeart Corporation, for developing heart assist pumps
- Moxtec, Inc. for manufacturing oxygen analyzers and monitors.

A wide number of Innovation Themes are found that are relevant to Medical Devices including:

- Surgical Instruments, Equipment and Devices
- Musculoskeletal Implants and Devices
- Cardiovascular and Pulmonary Conditions
- Medical Imaging
- Transplantation and Stem Cell Applications
- Ophthalmology
- Ion Channel Research.

Utah also stands out in the number of publications fields in which it is strong that relate to medical devices. These include: Biomaterials, Transplantation, Cardiac and Cardiovascular Systems, Imaging Sciences, Biophysics, Biomedical Engineering, Orthopedics and Neuroimaging.

Among the many university research centers and focus areas found in Medical Devices are:

- **University of Utah Cardiovascular Research and Training Institute**, which is focused on electrophysiology seeking to understand how both normal and diseased hearts generate electrical signals and how these signals modulate contraction. Such knowledge provides a basis for more effective treatment of arrhythmias and other disease states that effect ion movement across heart cell membranes.
- **University of Utah Bioengineering Department,** which brings an active focus on cardiovascular devices, neural engineering and through its Utah BioDesign, the advancement of novel devices through close collaborations with surgeons and other clinicians.
- **University of Utah Scientific Computing and Imaging Institute,** which is a renowned center of excellence with a core focus on biomedicine applications to address new image analysis techniques, visualization of complex and rich scientific data, advancement of computational and numerical methods for scientific computing and development of scientific software environments. SCI is home to the NIH funded Center for Integrative Biomedical Computing (CIBC), which is dedicated to producing open-source software tools for biomedical image-based modeling, biomedical simulation and estimation, and the visualization of biomedical data.
- **University of Utah Nano Institute,** which has faculty working on biomedical device innovation to improve the performance of implants and promote functional regeneration of tissue, along with work on polymer innovations for gene therapy and enhanced delivery of therapeutics.
- **Brigham Young University,** with has a focused effort on Compliant Mechanisms, which can advance novel biomedical devices through the use of microelectromechanical and nanoelectromechanical systems.

Molecular Diagnostics and Personalized Medicine

The growing knowledge of genomic and proteomic data linked to specific disease states or predisposition is fueling the rise of molecular diagnostics. Molecular diagnostics is not only a new tool for medical diagnosis; it is a gateway to personalized medicine. As we move forward in the second decade of the 21st century, the promise of personalized medicine remains largely ahead of us. Molecular diagnostics are integrally linked with the personalized medicine approach of pharmacogenomics, which considers how genetic variations or differences in gene expression affect the ways in which people respond to drugs. In fact, these personalized medicine approaches to understanding of how genetic variations affect reactions to different drugs can enable diagnostic tests to be established that can guide doctors to make more informed and cost-effective medication decisions for their patients.

HOW IT BUILDS ON UTAH STRENGTHS

Utah stands out in the strength of its medical testing laboratories, with 3,237 jobs in 2010, an increase of 91 percent since 2001. This industry has been growing more rapidly in Utah than nationally. Employment in this industry is 127 percent more concentrated in Utah than it is nationally. Of particular note for Utah is the presence of ARUP Laboratories, one of the nation's leading clinical and anatomic pathology reference laboratories. ARUP Laboratories was created in 1984 by the University of Utah School of Medicine's Department of Pathology, and has established itself as a role model for bridging the gap between academic medicine and successful business enterprise. Not only does ARUP Laboratories process more than 30,000–35,000 specimens of blood, fluid, and tissue samples each day, it has become a world leader in laboratory research and development having developed more than 400 clinical laboratory tests and improving and validating more than 200 others, while at the same time having an extensive publications track record in peer-reviewed journals.

While in vitro diagnostics does not stand out as a specific industry in Utah, the state is home to Myriad Genetics, one of the nation's leading molecular diagnostic companies with a broad number of diagnostic procedures related to cancer detection and treatment. Emerging diagnostic companies found in Utah include Sorenson Genomics, focused on verifying human identity and relatedness and Lineagen, with a diagnostic on the market for autism and ongoing scientific programs in the areas of multiple sclerosis (MS) and chronic obstructive pulmonary disease (COPD).

Utah also has a number of emerging biopharmaceutical companies advancing new diagnostics and testing products and services. Among the firms that received venture financing between 2006 and the first quarter of 2011 were:

- Numira Biosciences, LLC, a specialty contract research organization focused on analysis of tissue samples for disease progression, drug efficacy and drug side effects.
- Lineagen, Inc., focused on molecular diagnostics for autism.
- Axial Biotechnology, focused on the use of genetics and minimally invasive fusion-less devices to diagnosis human spine diseases.

- BioMicro Systems, Inc., developing micro fluid analysis technologies for genomics, proteomics, and diagnostics research.
- Sera Prognostics, providing diagnostics to predict and manage pregnancy complications.

Genomics and biologics stand out as distinct Innovation Themes based on the cluster analysis of patents and publications. Utah also stands out in a number of fields closely associated with molecular diagnostics, including Medical Laboratory Technology and Biochemistry and Molecular Biology

Among university research centers and focus areas there are several of note in the area of molecular diagnostics and personalized medicine. They include:

- The University of Utah's Nano Institute, which is focused on the development of nano-based diagnostics and therapeutics through the application of nanobiosensors for early disease detection, chromatography, and immunoassay applications.
- The Huntsman Cancer Institute, which is closely tied to the Department of Human Genetics at the University of Utah noted for its model systems work in genetics research involving C. elegans, drosophila, mice, and zebra fish.
- The NIH funded University of Utah Center for Clinical and Translational Science, a collaboration with Intermountain Healthcare, University Health Care, Utah Department of Health and the Salt Lake City Veteran's Administration. The Center is building on the university's strengths in genetics and bioinformatics to bring promising bench science into practice.
- Brigham Young University, which has faculty research ongoing in molecular diagnostics including development of lab-on-a-chip tools to detect and quantify clinically relevant biomolecules and development of new bioarrays for tissue analysis using mass spectroscopy in collaboration with the La Jolla Institute for Molecular Medicine (LJIMM).

A unique and well-established asset that will support the development of molecular diagnostics and personalized medicine in Utah is the Utah Population Database (UPDB), a resource that includes vast amounts of population-based information obtained by linking extensive data from genealogies, medical and cancer records, health care utilization histories, and demographic information. Large genealogies contained in UPDB are based on records from the founding pioneer families who settled Utah and their descendants. Through linkage with all birth certificates and other population data, the UPDB has extended the coverage of the genealogy information to the present. At its deepest, the UPDB has data on families that go back 12 generations. Combining genealogies with medical and vital records creates unparalleled synergies that have grown through record linkages to all University of Utah Health Care and Intermountain Healthcare medical records. UPDB now provides data to support over 125 active research projects. UPDB is the largest and most comprehensive genealogic and medical research database in the world, and a powerful tool for epidemiological, public health and health outcomes research. Two important objectives are to associate a biospecimen bank with UPDB and to connect UPDB records to environmental exposures in order to greatly expand its capacity for analysis on genetic and gene-environment studies in support of personalized health care.

Molecular Medicine; Drug Discovery, Development, and Delivery

With the recent advances in genomics and biotechnology, a new era of molecular medicine is revolutionizing the development of drugs from the traditional trial and error approach to a more predictive and systematic use of detailed information about the operations of cells and molecules to pursue more focused interventions on disease processes. In particular, the use of advances in genomics and proteomics combined with improved disease model systems and computerized or "in silico" high throughput screening is transforming our understanding of the structure and function of genes and proteins and leading to improved ability to identify new potential targets of intervention for diseases. An important use of "in silico" drug development is assisting in the pharmacological study of drugs to improve drug design for absorption, distribution, metabolism, excretion, and toxicity.

Drug delivery is also being advanced through the use of polymer-based drug delivery systems and nanotechnology. Advances in polymer science have led to the development of several novel drug-delivery systems, including biodegradable polymers that can degrade into non-toxic forms in the body, highly absorbent and responsive hydrogels that can be used as biosensors as well as in wound healing and tissue scaffolding, and novel supramolecular structures able to deliver biologics.

Often involved in novel polymers, but also useful in other materials for drug delivery, are advances in nanomaterials. Nanomaterials have a number of functions in drug delivery such as encapsulation to protect the drug and prevent it from reacting with non-targeted tissues during transport, and as functional drug carriers in targeted delivery systems. Nano-sized particles have higher rates of diffusion and solubility, the ability to penetrate the blood-brain barrier, lower immune rejection rates, better digestibility, and more precise timed release and thus increased efficacy. The key value of nanotechnology in drug delivery is the potential to make drugs more effective at lower doses, at minimal or no toxicity, and help convert drug candidates that are otherwise poorly soluble in water into viable products.

HOW IT BUILDS ON UTAH STRENGTHS

Utah's biopharmaceutical sector, including Pharmaceutical Preparation Manufacturing and Medicinal and Botanical Manufacturing is specialized and growing. Employment in Life Sciences Commercial R&D, though not yet specialized, grew by 34 percent between 2001 and 2010. The state's employment in Pharmaceutical Preparation manufacturing grew by nearly 26 percent; employment in Medicinal and Botanical Manufacturing grew by 8 percent during this time period. Utah also has a number of emerging biopharmaceutical companies that are advancing new therapeutics.

On the research side, a wide number of Innovation Themes in disease research, drug-related basic research, and pharmaceutical development are found in Utah. Based on an analysis of the content of patents and publications, we identified the following areas:

- Neurosciences
- Cancer
- Drug Development and Delivery

- Infectious Diseases, Pathogens and Immunology
- Diabetes
- Molecular Genetics and Cell Biology.

Utah also has major research centers that support the development of this area.

- The University of Utah College Pharmacy is one of the top National Institutes of Health funded colleges of pharmacy, nationally recognized in medicinal chemistry, pharmaceutics and pharmaceutical chemistry spanning drug discovery, evaluation, delivery and outcomes research.
- The Huntsman Cancer Institute is a National Cancer Institute-designated Cancer Center noted for its contributions in identifying the genetic mutations responsible for inherited susceptibility to a number of cancers, including neurofibromatosis, colon cancer, breast cancer, and melanoma. It also has an active experimental therapeutics research thrust and is building capacity for early phase clinical trials.
- The University of Utah Molecular Medicine Program is an interdisciplinary effort to support and train physician researchers, who are critical to advancing novel treatments for a variety of human diseases and conditions, including cardiovascular and diabetes/metabolism. It is closely aligned with the clinical departments at the University of Utah, the Department of Human Genetics and the Utah CTSA. It also organizes the core faculty to support the MD-PhD program, Summer Medical Research Program, Howard Hughes Medical Institute med-to-grad PhD track, and other NIH-funded training programs.
- Brigham Young University's Cancer Research Center involves 17 faculty members from across the Colleges of Physical and Mathematical Sciences, Life Sciences, Health and Human Performance, and Engineering and Technology, who are working on cancer-related drug and diagnostic discovery, cancer biochemistry, cancer genetics, cancer immunology, and cancer epidemiology and bioinformatics. Among its most active programs are screening for anti-cancer molecules, use of DNA microwires for cancer detection, and genetic processes involved in cell division.
- Other biomedical research under way at BYU includes research into genetic risk factors for Alzheimer's disease; research into targeting AMP-activated protein kinase for prevention and treatment of type 2 diabetes; and Research into HIV treatment to address reservoirs or sites where HIV escapes intervention by drugs or the immune system.

Natural Products and Dietary Supplements

According to the Dietary Supplement Health and Education Act of 1994, a dietary or nutritional supplement is any product that contains one or more dietary ingredients such as a vitamin, mineral, herb or other botanical, amino acid, or other ingredient used to supplement the diet. Dietary supplements come in a variety of forms: traditional tablets, capsules, and powders, as well as drinks and energy bars. Popular supplements include vitamins D and E; minerals like calcium and iron; herbs such as echinacea and garlic; and specialty products like glucosamine, probiotics, and fish oils. Dietary supplements are not food additives (such as

saccharin) or drugs. It is estimated by the NIH Office of Dietary Supplements (ODS) that Americans spend about $25 billion a year on dietary supplements and at least 50,000 products are available that contain dietary supplements.

There is an active effort at the National Institutes of Health to investigate the potential roles of dietary supplements in promoting health and reducing the risk of chronic disease. Much of this work is done in concert with other NIH institutes and centers. ODS also engages its federal partners in activities to fill essential needs that would not otherwise be addressed. In 2010, 89 NIH-supported projects focused on the health impacts of dietary supplements for conditions such as age-related disease, anti-cancer activity, bone health, inflammatory disease prevention, asthma, cardiovascular disease, heart failure, sickle cell disease, malaria, maternal and child health, obesity, and diabetes, among other health conditions.

HOW IT BUILDS ON UTAH STRENGTHS

Utah is already a leading center for the nutritional supplements industry. A detailed listing compiled by the Utah Technology Council identified more than 100 natural products and dietary supplement companies in Utah. It is estimated that these companies account for 20 percent to 30 percent of the entire U.S. market. In the North American Industry Classification System there is no specific industry classification that fully encompasses the natural products and dietary supplement companies. Some of these companies are classified as Medicinal and Botanical Manufacturers. This industry is 3.3 times more specialized in Utah than the nation and grew by 8 percent from 2001 to 2010, reaching 760 jobs in 2010. Other companies are classified as Pharmaceutical Preparation Manufacturers, which is 105 percent more concentrated than the nation and grew a robust 25.6 percent from 2001 to 2010, and reached 3,892 jobs in 2010.

The nutritional supplement and functional foods area stands out as a distinct Innovation Theme based on the cluster analysis of patents and publications activities. The types of activities include research on the use of supplements to treat diseases, chemical analysis of nutritional content, probiotics, and impacts of fiber intake on weight reduction, and improved content of cheese production.

In scholarly activity, Utah stands out in nutrition and dietetics with 117 publications from 2005 to 2009, which represents 1.2 percent of all U.S. publications. Particularly impressive is that Utah is 174 percent higher in the level of citations per publication, a measure of quality of publications, than the national average.

A key new university resource in the area of nutritional supplements and functional foods is Utah State University's Center for Advanced Nutrition, supported by USTAR. The Center includes a newly constructed 110,000 sq ft building at the USU Innovation Campus with state-of-the-art metabolic kitchen and research facilities in which clinical research can be conducted in collaboration with industry. Currently the Center works with food and natural product companies in and outside the state of Utah to help them better substantiate claims and identify new health-related properties for their products. Among the key research efforts under way at the Center are research to identify plant or animal compounds with health benefits that can fight obesity, type II diabetes and cardiovascular disease, research into gut biology and ways to control the appetite for dietary fat, and research on the neurological and biological impacts of fatty food consumption and exercise on the brain as a determining factor for type II diabetes and obesity.

Competitive Assessment of Utah's Life Sciences Industry Cluster

It is clear from the above discussion that Utah has a strong base on which to continue to build its life sciences industry cluster. Indeed the state is well positioned to capitalize on rapidly expanding markets for personalized medicine, new medical devices, nutritional supplements, and biopharmaceuticals. But realizing the opportunities described above will require that Utah maintain a competitive position in the life sciences and address any existing gaps in its life-science infrastructure.

To be a leader in the life sciences, Utah must ensure that the state has:

- A robust life-science R&D infrastructure committed to engaging with locally-based life-science companies and facilitating commercialization of life-science discoveries
- A significant pool of talent in the life sciences disciplines
- Available capital able to support life-science companies through all stages of development
- A supportive business climate.

Research and Commercialization Infrastructure

To become a major life sciences center, a state must have a strong, world-class higher-education presence, with leading-edge researchers and clinicians in the medical, life, and biological sciences. The hallmarks of a respected life sciences center today are medical centers and teaching hospitals, multidisciplinary centers, and modern facilities, well-equipped for state-of-the-art research.

Life-science research programs can flourish only if they have world-class researchers and access to an excellent physical infrastructure. This infrastructure includes state-of-the-art laboratory facilities and equipment, telecommunications capacities, computer systems and software, and the buildings to house all of these elements. It also includes the creative use of land and other holdings in support of the R&D enterprise.

Having a robust life-science R&D enterprise is but one step to success. The research community must be committed to commercializing research discoveries and must have at their disposal a support infrastructure to enable them to successfully develop and introduce new products or services and start-up new businesses.

The strengths of Utah's research universities in the life sciences disciplines are considered a major competitive advantage by Utah's life sciences industry. Academic R&D in life sciences disciplines increased by 66 percent between 2001 and 2009, growing to $280 million. While this growth is impressive, the rate slightly lagged growth in academic life-science R&D at the national level. Utah performed very well, however, in terms of NIH funding, considered the gold standard of life-science R&D. The value of Utah's NIH awards increased 25 percent between 2005 and 2010, much faster than at the national level, which grew only 5 percent. This increase in NIH awards suggests that Utah researchers are performing at a very high level.

As stated above, having a cutting-edge life-science research enterprise is only the first step; leveraging that base for economic development requires translating research discoveries into commercial products and services. Utah universities have a history of spinning off life-science companies based on university-developed

technologies. Myriad Genetics, Watson Pharmaceuticals, Coherex, Lineagen, and Sera Prognostics are examples of Utah life-science companies that were developed based on university discoveries. The universities also have taken steps in the past five years to restructure their technology transfer and commercialization activities, and to encourage and support faculty seeking to commercialize their research findings.

These initiatives, while positive, need to be expanded and applied comprehensively for Utah to assume a leadership role in life sciences. There are still opportunities to further the linkages between university research and industry development. The majority of life-science business leaders interviewed reported that they did not often collaborate with Utah universities. Among those that did collaborate, there were frequent comments on the need to address difficulties encountered in trying to negotiate licensing agreements and/or putting sponsored research contracts in place.

Talent

Ensuring the availability of an educated, skilled workforce is pivotal to developing and sustaining a robust life sciences industry cluster over the long term. Those states and regions that effectively address life-science workforce needs will be in a stronger position to grow and develop their life sciences industry clusters. Across occupations and careers in the life sciences, the skills required extend beyond high school, even for production- and technician-level workers. Nearly all careers in the life sciences disciplines require post-secondary education that combines scientific principles and applied laboratory techniques. High school programs related to career development in the life sciences disciplines are best viewed as a first step in a structured pathway to life-science careers, based on industry standards and closely aligned with post-secondary education offerings.

Factors Driving Life-Science Workforce Needs

- Fast pace of innovation drives new skill development in the life science—stronger emphasis on technology skills along with life science knowledge
- Critical skill shortages can emerge quickly and pose major impediments to industry growth in niche areas
- Breadth of life science—involving research, manufacturing, and services—drives broad workforce skill demands
- Post-secondary education for life science positions, even in more production-oriented activities, is important
- Specific cross-cutting occupational skills are needed in good laboratory and manufacturing practices

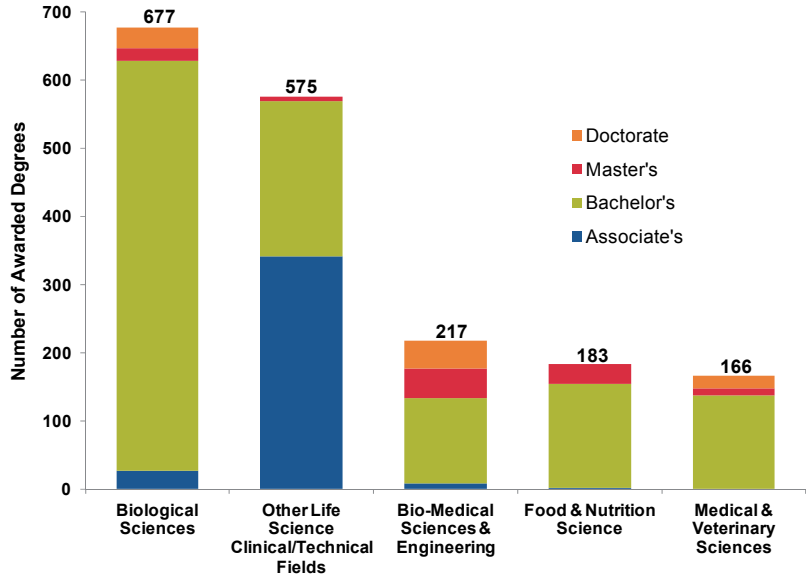
Nationally, states have become very aggressive in addressing the talent needs of the life-science sector. Across the board, states are implementing new program offerings at all levels of education, including K–12, community college, undergraduate, and graduate; new programs combining business with life sciences education; and new types of degree offerings to address the need for people with expertise in regulatory affairs and clinical trials. New life sciences and biomedical institutes have been formed, some of which are multi-institutional; and specialized science and technology high schools and biotechnology magnet programs have been instituted. States are working with the life sciences industry to develop career pathways, offering programs to equip teachers with life-science skills and knowledge, and encouraging existing workers to retrain for careers in the life sciences.

Utah has been making considerable gains in terms of bioscience-related college degrees awarded. From 2003 to 2009, the number of bioscience-related college graduates in Utah increased from 1,225 to 1,818, a gain of 48 percent. By comparison, the number of bioscience-related college graduates in the U.S. increased by

43 percent. As a percentage of all college graduates, Utah now equals the U.S. average of 4.8 percent of all college graduates obtaining degrees in bioscience-related fields.

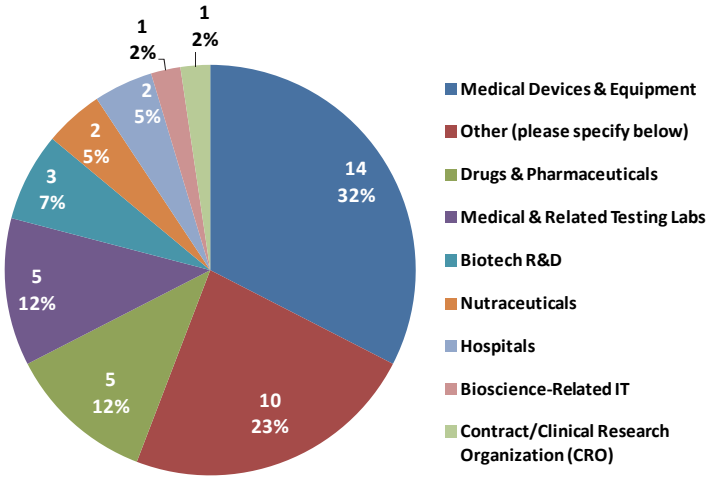
Utah generates a broad mix of bioscience-related graduates. Biological sciences and clinical/technical fields accounted for the largest number of degrees in this area. Still, there were sizable numbers of degrees awarded in bioengineering, food and nutrition sciences, and medical/veterinary sciences. Further analysis revealed that the share by level of degree—associate, bachelor's, master's, and doctorate—was largely in line with the overall U.S. with a slightly higher focus on bachelor's degrees and lower emphasis on master's degrees in Utah compared to the U.S.

Figure 4: Bioscience-related Degrees in Utah by Broad Category and Level, 2009



On a general level, Utah life-science employers report that Utah's workforce is a major advantage. It is well-educated, has an excellent work ethic; by and large employers are able to find the talent they need. But specific positions, particularly in the regulatory affairs and quality control areas, are difficult to fill locally, and it can be difficult to recruit experienced life-science workers to relocate to Utah, because Utah's life sciences industry cluster is still small and because of the image that they have of Utah. Given the importance of on-going regulatory changes governing this industry, having access to talent and skills in this area is critical to the growth of the sector.

Figure 5: Respondents by Industry (Note: first figure is number of companies, second is share of industries)



To better understand the workforce needs of Utah's life-science companies, Battelle conducted a web-based workforce survey to collect data on recent workforce trends, skill requirements, expectations, issues, and challenges. Forty-three companies and institutions responded to the survey. About one-third of the respondents were medical device companies. The respondents reported employing more than 6,000 workers, about a 1,000 of which had been hired in the past year.

Looking forward, the number of vacancies and expected hires in the year ahead is substantial, together exceeding over 1,000 positions. This is consistent with findings from the Utah Technology Council that there are thousands of high skilled job openings—or what UTC terms "hot jobs"—in Utah across life sciences and information technology companies.

Table 4: Current and Future Life Science Workforce

Occupations/Major Job Functions	Current & Future UT Life Science Workforce			
	Existing	Recent New Hires	Current Vacancies	Expected New Hires
Utah Totals*	**6,090**	**1,043**	**215**	**831**
Research Scientist	183	31	9	25
Research Technician	245	34	9	**48**
Medical/Clinical Lab Technician	**1,030**	**72**	**27**	**52**
Clinical Trial Coordinator	104	14	2	14
Health/Bio Informatics	69	13	6	3
Engineering-Product Development or Research	144	18	4	35
Engineering-Process Development	109	19	**17**	25
Engineering Technician	80	10	2	28
Quality Assurance/Control/Validation	263	50	14	**43**
Manufacturing and Production	**1,043**	**195**	**25**	**414**
Technical Support	**1,234**	**393**	**62**	22
Marketing and Sales	**894**	**88**	**17**	**76**
Regulatory Affairs	79	9	2	17
Other	**613**	**97**	**19**	29

New Hires = since August 1, 2010
Expected New Hires = in the next 2 years including filling any current vacancies
Figures in Red Shading represent the Top 5 responses from each workforce category.

The largest current occupational groups are also projected to see the largest near-term hiring particularly in Production and in Marketing/Sales.

Relative to their current levels, some strength is expected for hiring in the following job categories:

- Manufacturing/Production
- Engineering Technician
- Engineering – Product R&D
- Regulatory Affairs
- Research Technician.

The respondents were asked to rank each occupation on a scale of 1 to 5 in terms of the difficulty of finding qualified candidates. The positions most difficult to fill were regulatory affairs, quality assurance, clinical trials coordinator, engineering-process development, and health bio-informatics. Firms indicated that they do not have much difficulty filling research technician, manufacturing, and product and technical support positions. The majority of firms recruit nationally as well as locally for most occupations, although recruitment for technician positions is more likely to be done within Utah.

It is clear that the vast majority of life-science jobs in Utah require post-secondary education, with a high percentage of positions requiring at least a Bachelor's degree. See Table 5.

Table 5: Educational Requirements by Occupation

Occupation/Major Job Function	No Diploma	High School/GED	Vocational Training/Certificate	Two-year/ Associate's Degree	Bachelor's Degree	Master's Degree	Ph.D.	Share of Responses Bachelor's or Higher
1. Research Scientist	0	0	0	2	6	**14**	**23**	96%
2. Research Technician	0	2	3	**12**	**19**	5	1	60%
3. Medical/Clinical Lab Technician	0	2	3	**12**	**9**	1	1	39%
4. Clinical Trial Coordinator	1	0	0	3	**9**	**10**	5	86%
5. Health/Bio Informatics	0	0	0	2	**8**	**8**	4	91%
6. Engineering-Product Development or Research	0	0	0	2	**18**	**14**	1	94%
7. Engineering-Process Development	0	0	0	2	**22**	**8**	2	94%
8. Engineering Technician	0	2	4	**14**	**10**	4	1	43%
9. Quality Assurance/Control/Validation	0	2	**6**	5	**24**	3	1	68%
10. Manufacturing and Production	3	**12**	3	6	**11**	3	1	38%
11. Technical Support (e.g., Logistics, Documentation, etc.)	0	**10**	5	9	**12**	1	1	37%
12. Marketing and Sales	0	1	0	**8**	**23**	7	1	78%
13. Regulatory Affairs	0	1	1	4	**19**	**9**	2	83%
14. Other	0	**4**	3	**4**	**8**	3	3	56%

It is also clear that most employers in the life sciences fields are looking to hire people with some work experience, preferably in a related field. See Table 6.

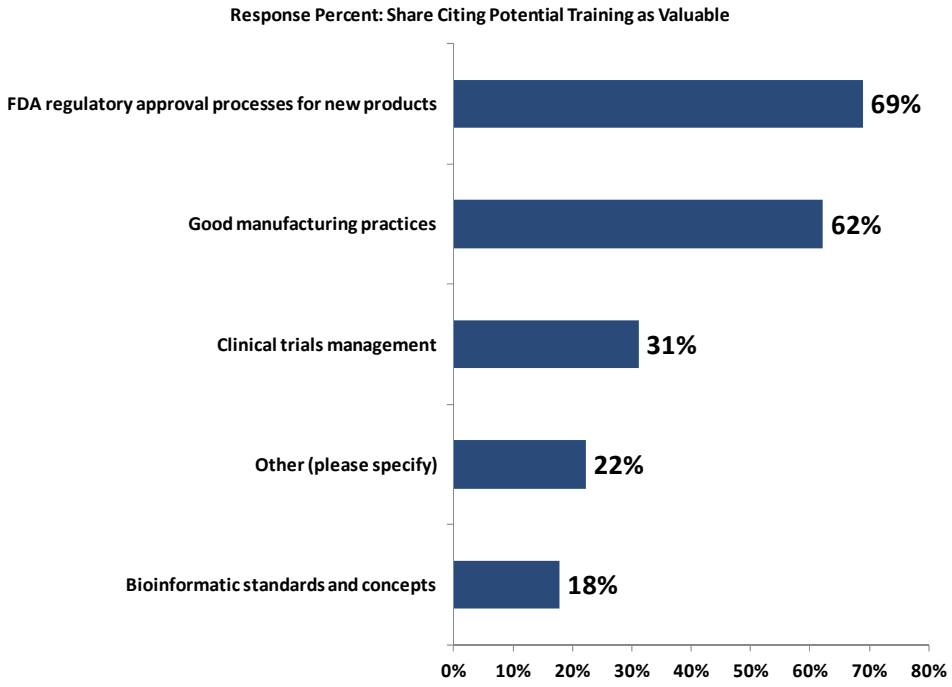
Table 6: Requirements for Work Experience

Occupation/Major Job Function	Education Only - Would hire directly out of school	Education plus some work experience	Education plus experience in a related field	Education plus experience in this occupation/technical area
1. Research Scientist	3	10	**13**	**23**
2. Research Technician	8	**18**	**11**	4
3. Medical/Clinical Lab Technician	**8**	**11**	**8**	2
4. Clinical Trial Coordinator	0	**7**	**9**	5
5. Health/Bio Informatics	0	**4**	**9**	3
6. Engineering-Product Development or Research	3	**8**	**16**	**8**
7. Engineering-Process Development	3	**9**	**13**	6
8. Engineering Technician	6	**12**	**10**	2
9. Quality Assurance/Control/Validation	3	**13**	**18**	6
10. Manufacturing and Production	10	**14**	**11**	2
11. Technical Support (e.g., Logistics, Documentation, etc.)	7	**19**	**9**	3
12. Marketing and Sales	5	**11**	**13**	**11**
13. Regulatory Affairs	3	6	**15**	**11**
14. Other	4	**6**	**9**	3

Note: Top 2 response counts for each occupation are shaded in red

The survey responses confirmed that the areas of greatest need for training were in the areas of Regulatory Policy and Good Manufacturing Practices, as set out in Figure 6. Additional topics that were suggested for training in an open ended question included SBIR Management, International Regulatory Policy, Six Sigma, and Lean Manufacturing.

Figure 6: Perceived Value of Potential Training



It is clear that as Utah's life sciences industry cluster continues to grow, demand for skilled workers will increase accordingly. This translates to a real opportunity for Utah's life-science companies to work in partnership with the state's educational system and industry organizations to identify workforce needs and to develop programs that address them.

Capital

Most people realize that the discovery of new knowledge resulting in the development of new technologies is a very expensive process running, in some cases, into millions of dollars. What many people do not realize is that the costs associated with developing and taking a technology product or service to market are also very substantial. Major costs incurred after the research has been completed include the cost of assessing the market to determine the competition, the likely market, and the price points for competitive advantage; developing a prototype; preparing a marketing and sales plan; and scaling up for manufacturing. Finally, actual product distribution, sales, and marketing must be undertaken. These activities require the availability of sufficient capital to finance business growth and economic development.

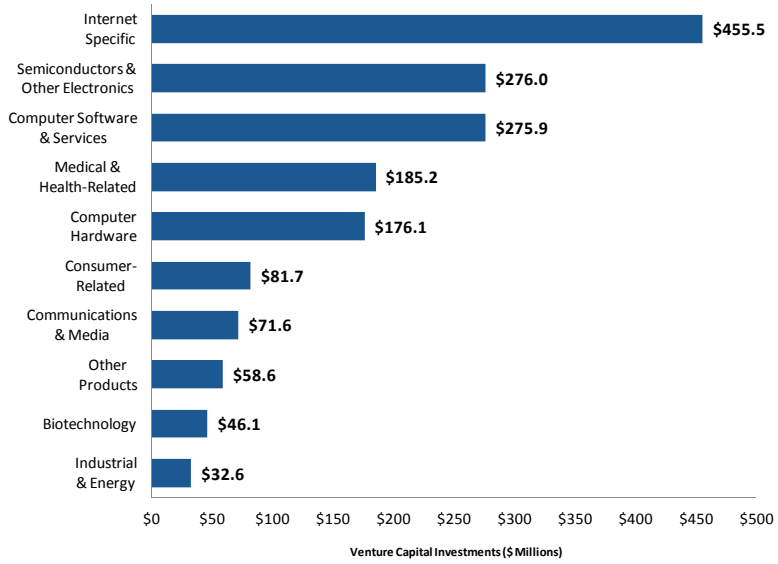
While these needs apply to all technology-based companies, many life-science companies, particularly those involved in biomedicine, need to access larger amounts of capital for longer time periods to cover the time needed to complete clinical trials and obtain regulatory approvals before products can be introduced into the market.

Yet, few sources of funding bridge the gap between the points at which (1) a discovery has been identified and demonstrated and (2) a business case has been validated and venture or other debt capital can be obtained. It

is also difficult to obtain seed and early-stage investment because venture funds, as they have become larger, tend to make larger, later-stage investments. As a result, angel investors have also moved downstream (further away from pre-seed and seed investments), making more post-seed and later-stage investments than previously. This trend has been exacerbated during the recession which has caused venture firms to invest primarily in their portfolio companies who do not have other options for accessing capital. So, in addition to the difficulty of obtaining translational research and pre-commercialization funding, firms are facing a gap at the start-up phase, as well.

Venture capital funds invested approximately $1.7 billion in Utah-based companies between 2006 and the 2nd Quarter of 2011. But the majority of these funds were invested in Utah's information technology and electronics firms. Only 14 percent of total venture capital investments were invested in life-science companies during this time period. See Figure 7 below.

Figure 7: Venture Capital Investments in Utah Companies, 2006–2nd Q 2011



Source: Battelle calculations – based on Thomson Reuters VentureXpert data.

A closer look at the investment by stage suggests that investments in ventures in the life sciences disciplines are not only a small share of total venture investments in Utah, but also are particularly lagging at the seed and early stage. Overall Utah leads the nation in its level of seed and early stage venture capital investments as shown in Table 7. However, in life sciences investments, Utah lags behind the U.S. average.

Table 7: Venture Capital Investments by Stage for Utah and the U.S., 2004–Q2 2011

Stage	Share of All Life Sciences Investments		Share of All Industry Investments	
	UT	U.S.	UT	U.S.
Seed	6.6%	7.2%	4.2%	3.1%
Early Stage	16.7%	19.7%	15.6%	11.8%
Expansion	32.6%	24.4%	24.8%	23.1%
Later Stage	21.6%	32.8%	30.0%	23.8%
Acquisition	6.5%	7.7%	14.6%	24.2%
Public Market	15.1%	6.5%	10.3%	11.2%
Other	0.8%	1.8%	0.6%	2.9%

Source: Battelle calculations – based on Thomson Reuters VentureXpert data.

A majority of the life-science entrepreneurs and CEOs of start-up companies reported that it is very difficult to obtain venture capital in Utah. There are few locally-based venture funds, particularly funds available for investment in life-science companies, and it is difficult to attract capital from out-of-state without a local partner. Utah has several angel investor groups including Salt Lake Life Science Angels, Park City Angels, and Utah Angels. With the exception of Salt Lake Life Science Angels, Utah's angel investors are investing in Utah's information technology and digital media companies, but they are less of a source for life-science companies, particularly given the large capital requirements and long timeline for the development of biomedical products.

Supportive Business Climate

Technology-based companies, like any business, consider a variety of factors when deciding where to locate a facility. They consider costs, availability and quality of the workforce, transportation infrastructure, real estate markets, the regulatory environment, and quality of life factors. Life-science companies need a regulatory environment that encourages and supports the growth and development of their industry and tax policies that recognize the long development cycle required to bring new life-science discoveries to the market. Responsiveness by state and local governments to regulatory, permitting, and other requirements can significantly impact where life science firms stay, grow, or expand.

Utah's business climate is a key strength that has resulted in economic growth in recent years. In 2010, Forbes Magazine ranked Utah as the number one state for doing business in the U.S. CEOs interviewed for this project reported that the state is very business friendly and that they are able to access local- and state-level policymakers. Utah's geographic location and transportation infrastructure were also cited as major advantages. Utah is a central location to major western cities and states, with a one- to two-day access to half the nation's population. It has multiple modes of transportation and distribution that are easily accessible.

With its location on the Canada/Mexico corridor, Utah is an excellent location for product distribution. Salt Lake City airport offers service to more than 100 cities and numerous international locations. Utah has lower costs, and companies reported no difficulties in terms of finding facilities. Utah is recognized as having a good business climate and an excellent quality of life, with many recreational and cultural amenities. All of these factors make Utah an attractive location for life-science companies.

Critical Issues to Address

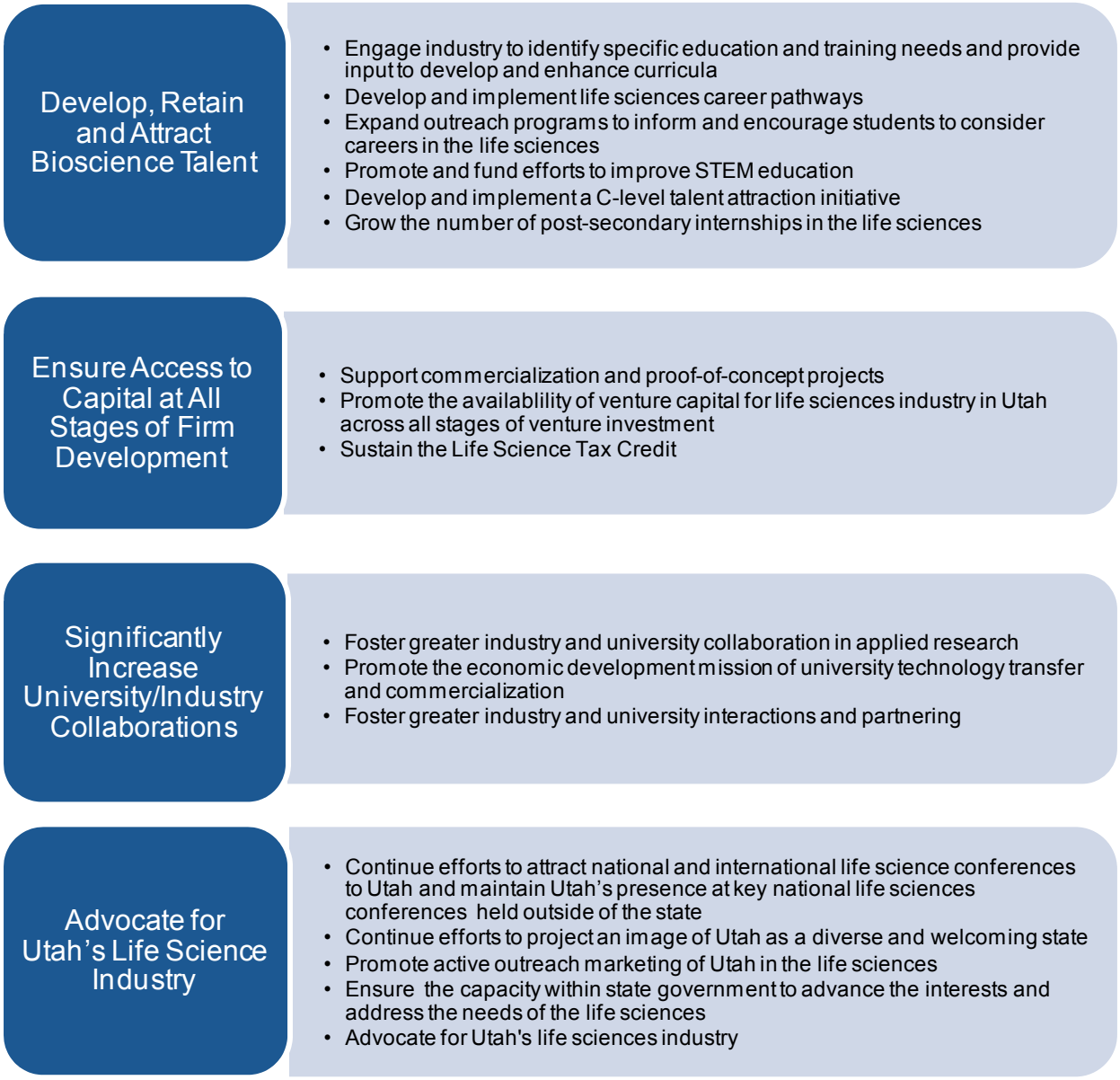
In order to significantly accelerate the growth of Utah's life sciences industry cluster, the following issues must be addressed:

1. **Utah must put in place a comprehensive approach to advancing talent development in the life sciences disciplines.** This effort must work at each level of the talent pipeline from K–12 to post-secondary education to workforce development, seeking out ways to create linkages through promoting STEM education, career pathways, internships, and employer guided curriculum and certificates, among other actions.
2. **Actions must be undertaken to address life-science companies' capital needs.** For Utah, the need is across all stages of life-science firm development from proof-of-concept to seed funding to more formal rounds of venture capital investment.
3. **Utah should better leverage its university research base by maximizing industry/university collaboration.** Such collaboration is needed not only to move research discoveries into the marketplace but also to help Utah's life-science companies move up the value chain so that they are producing higher value-added products and services.
4. **Utah should undertake a branding and marketing campaign to promote the state as a center for the life sciences.** These efforts need to raise the profile of Utah in the life sciences by making the state a destination for life-science business executives as well as address the image of Utah as a diverse and welcoming place. The success of these efforts depends upon having the staffing and resources in place to leverage the growing presence of life sciences in Utah.

Acceleration Strategies and Actions

Four strategies are proposed to accelerate the development of Utah's life sciences industry cluster. The four strategies and the specific actions to achieve them are shown in Figure 8.

Figure 8: Utah Life Sciences Acceleration Strategies and Actions



Develop Retain and Attract Life-Science Talent

RECOMMENDATION #1: ENGAGE INDUSTRY TO IDENTIFY SPECIFIC EDUCATION AND TRAINING NEEDS AND PROVIDE INPUT TO DEVELOP AND ENHANCE CURRICULA.

In Utah, as elsewhere, life-science business executives indicate that they have difficulty finding qualified candidates across a range of occupations. This suggests that the state's educational institutions do not have sufficient information on the skills that are needed or the demand for different types of education and training programs. In addition, resources are limited to initiate new course and degree offerings.

Utah will need both a long-term and short-term strategy to address the educational gap. Over the long term, Utah needs a bioscience workforce effort that has the resources to work alongside education and training providers to help create the programs, curriculum, instructional labs, and teacher professional development that respond to the specific needs of the life sciences industry. This effort should leverage industry data available through targeted industry surveys and regularly collected data by the department of workforce services. It should also seek to streamline the process of customized training and industry feedback to educational institutions.

In the short-term, it is important for Utah's post-secondary institutions to work with Utah's bioscience industry to remedy urgent educational needs in quality regulatory affairs, quality assurance, clinical trials coordination, engineering-process development and health bio-informatics. Educational institutions should explore expanding or developing partnerships with industry associations and societies (e.g., UTC, Intermountain Biomedical Association, MD4, American Society of Quality Salt Lake City, or the Regulatory Affairs Professionals Society). The focus of this effort should include post-secondary students, but also targeted continuing education for current industry employees.

RECOMMENDATION #2: DEVELOP AND IMPLEMENT LIFE SCIENCES CAREER PATHWAYS.

Despite the presence of many educational programs in Utah, life-science business executives report that they have difficulty filling some positions locally; demand for skilled workers will only increase as the industry grows. It is recommended that Utah develop a coordinated and systematic statewide approach to developing life sciences career pathways and workforce development in the life sciences disciplines. A preliminary life-science career pathway is included in the Appendix. This should build upon current program articulations for biotechnology and associated life-science degree programs across high schools, community colleges and 4-year degree colleges. Existing programs may need to be expanded or new programs established to meet any gaps identified in the career pathway. The development of the career pathways should be done in conjunction with partners such as UtahFutures.org or the Utah Career and Technical Education Career Pathways project to create greater student and advisor visibility and to improve integration into current state projects.

A variety of programs in Utah designed to educate students for careers in the life sciences industry offer a base to grow and expand additional career pathway programs in the life sciences. Salt Lake Community College (SLCC) has a Biotechnology Program that provides the knowledge and skills needed to operate in a life-

science laboratory environment. Students can receive an Associate of Applied Science or Associate of Science degree in Biotechnology. Students receiving the latter can transfer to Utah Valley University's 4-year BS in Biotechnology program. To make it easier for students to complete the 4-year program, UVU faculty members teach classes on the SLCC campus. Classes are also offered at the UVU campus. UVU's biotechnology program has been in place since 2007.

SLCC and the Granite Technical Institute offer a biomanufacturing program that train college and high school students respectively. The core focus of the college program is on quality systems and regulations that pertain to the biotechnology industry. The high school program emphasizes training in quality systems and regulation as they apply to the medical device industry and analytical testing (safety and ingredient characterization) for dietary supplements and natural products. What stands out in this biomanufacturing program is that high school students in the program have an articulated pathway to complete a certificate, diploma, or Associate of Applied Sciences degree. With the criticality of the regulatory hurdle for industry growth, stackable certificate and degree programs should be developed and articulated with all Utah higher education institutions.

The Utah State University Center for Integrated Biosystems offers intensive training programs in biotechnology and bioprocessing, as well as a five-day summer academy for high school students, a symposium for 7th to 12th grade science teachers, and tours for high school classes.

BioInnovations Gateway (BiG) is a unique program that seeks to incubate life-science companies while training the next generation of life-science workers. It includes a 25,000 square-foot facility located on the property of Granite Technical Institute (GTI) that is equipped with a wet lab, a rapid prototyping lab, a computer-assisted design lab and a clean room. GTI's biomanufacturing program is aligned with SLCC's biomanufacturing program and provides instruction for high school students, who spend part of the day at their home school and part of the day at BiG participating in industry-sponsored internships. BiG also functions as a business incubator, providing space and support for up to 7 start-up life-science companies. The companies are encouraged to use students, both high school and community college students, to work with them. This not only provides the students with hands-on experience but builds their entrepreneurial skills by exposing them to the process of starting a business.

Another program at BiG is BioInnovate in which student teams undertake design projects for private companies. Essentially, BioInnovate is a student-run product development enterprise, operating like a private contract research organization. Through the program, students in GTI's biomanufacturing program learn to operate in a GMP environment. Another innovative effort that focuses on educational opportunities for college students to work on advancing new medical product prototypes is BioDesign at the University of Utah, in which bioengineering students work with clinical partners from the medical school to develop and commercialize biomedical products and related technologies.

RECOMMENDATION #3: EXPAND OUTREACH PROGRAMS TO INFORM AND ENCOURAGE STUDENTS TO CONSIDER CAREERS IN THE LIFE SCIENCES.

The first step in filling the life-science talent pipeline is to interest students in science, math, and engineering and inform them about possible careers in the life sciences disciplines. Experiential learning and career awareness programs, which can range from field trips, summer camps, workshops and internships, are designed to accomplish this. Such programs are widespread across the country. A study prepared by Battelle in 2009 found that every state had one or more experiential learning and outreach programs in the sciences and the majority of states had programs focused on biosciences.[3] While the programs were numerous, most were grant-funded and, as a result, often come and go as grants end at one institution and begin at another. Many outreach programs, such as summer camps, reach only a small number of students on an annual basis; many focus on servicing high-achieving students with an already-established interest in science or math.

A similar situation exists in Utah. Individual institutions, including museums, colleges, and universities, offer science outreach programs, but many of these programs struggle to maintain funding and are able to reach only a small number of students and their parents. Weber State University is particularly active in terms of outreach activities. Its Museum of Natural Science offers Science Saturdays that allow families to participate in hands-on activities. Science in the Parks is offered in downtown Ogden in order to reach a larger number of people, including more disadvantaged students. The college also has a seminar series, S4, which is designed to interest high school and junior high school students in science. The University initiated Science Moms, a pilot program that showed mothers activities they could do at home with their children. Despite a high level of interest in these and other programs, funding has been cut during the last several years due to pressures on the University's overall budget. Other colleges and universities offer similar programs.

In Salt Lake City, The Leonardo offers a contemporary, hands on science, art, and culture center to provide students and the broader community a unique, interactive approach to fusing science, art, and culture. Through immersive exhibits, real-life labs, and community workshops, students get a hands-on experience to advance their interests in science and technology. Dr. Mario Capecchi, a Nobel Laureate from the University of Utah, serves as the senior advisor at The Leonardo involved in reviewing the programming and exhibits in The Leonardo. In this capacity and along with his staff, he provides advice on The Leonardo's plans through periodic meetings, generates ideas and suggestions on concepts and intellectual resources to fulfill the mission, and works closely with The Leonardo to bring real science from the labs at the University of Utah to the community.

Another important initiative is Utahfutures.org, a one-stop career information system for students, parents, and school counselors, as well as for those already in the workforce. It features assessments to help identify a student's interests and aptitudes, career exploration and planning tools, education and training options, and the ability to create a personalized online portfolio to store information generated by a student in their career exploration efforts, among other features. Outreach programs should be supported and marketed. Life-science companies can help by both providing financial support but also by encouraging employees to participate in such efforts. Consideration should be given to creating a program, specifically focused on the life sciences and ways should be explored to make such activities available to a larger number of students. Finally, stronger

relationships should be forged between secondary and post-secondary partners that result in stronger and more effective outreach programs that are sustained over the long-term.

RECOMMENDATION #4: PROMOTE AND FUND EFFORTS TO IMPROVE STEM EDUCATION

A prerequisite to filling the life-science talent pipeline is to make sure students are well prepared in science, technology, engineering, and math (STEM) to enable them to pursue degrees that would allow them to become life-science workers. Life-science company executives expressed their concerns in interviews about the quality of Utah's science and math education at the K–12 level both in terms of finding future workers but also because it impacts a firm's ability to attract highly skilled workers who may be unwilling to relocate to Utah if they think there are deficiencies in public education.

An analysis conducted by the Utah Foundation examined Utah's performance on National Assessment of Educational Progress (NAEP) math, science, and reading tests from 1992 to 2009.[4] They found that:

- Utah is underperforming compared to states with similar demographics in terms of its math, science and reading scores. When compared to a number of peer states, Utah most often ranks last in these tests.
- In addition to persistently low peer-state rankings over the past two decades, Utah's national ranking on these exams has fallen significantly.
- Utah's math scores have increased over the years, but other states' scores have risen faster, resulting in a lower ranking for Utah. Reading scores have been flat for Utah during this period. Utah's science scores are higher than the national average, but at the bottom of peer states.

Utah has in place a number of efforts to improve STEM education. The **Utah Science and Mathematics Education Consortium** is a coalition of the science deans from all the colleges and universities in the state, teamed with representatives from public education and industry. The goal of this group is to promote programmatic cooperation among the state's institutions of higher education, as well as to develop a better dialog between higher education and K-12 schools.

The **Center for Science and Mathematics Education** (CSME) was established in fall, 2009 at the University of Utah within the College of Science and the College of Education. The mission of CSME is to facilitate, coordinate, and implement collaboration between the two Colleges as well as with Utah school districts. The Center was created to address the need for employees with highly developed mathematics science and engineering knowledge and skills, as well as, to satisfy the critical need for more qualified teachers of mathematics and science.

Weber State's **Center for Science and Math Education**, as described above, offers a large number of outreach programs designed to interest students in math and science. Utah State University is in the process of creating a **STEM Education Center** which will conduct R&D on STEM education, offer professional development opportunities for STEM teachers, and perform outreach activities aimed at interesting students in STEM.

The **Utah Education Network** has created a **STEM** (Science, Technology, Engineering, and Mathematics) **website**, which connects students, teachers, counselors, parents and others to the many programs, opportunities, and services available to students who wish to participate in math and science programs. Many opportunities are embedded in the State's colleges and universities. Others are offered by the network of museums, libraries, and similar organizations that provide programs that complement formal studies in math, science, and engineering.

The Utah Technology Council (UTC) has been particularly active in advancing STEM programs and policies in Utah. Through the efforts of UTC staff and member companies, strong industry support has been mobilized to advance major STEM initiatives in Utah, including enhancing the state's graduation requirements in math and science, establishing Utah's Engineering Initiative and support for funding of these and other STEM initiatives. What is needed going forward is a coordinating effort to maximize the reach and effectiveness of ongoing STEM activities. It is particularly important to create a single place where input and guidance from industry can be shared across programs, and industry awareness and engagement can be promoted. It is also important to have a statewide, sustained outreach and marketing effort of the state's many STEM related programs to students and their parents. This is especially important for the emerging efforts to educate and train students in career opportunities in the life sciences.

At the same time, these efforts in STEM education are critical to advancing the attractiveness of Utah in recruiting high skilled life-science workers and their families to the state. A particular concern expressed in the industry interviews is that as K–12 education in Utah is slipping, Utah becomes less competitive for attracting life-science workers, especially compared to other fast growing life sciences hubs, such as Maryland and North Carolina.

RECOMMENDATION #5: DEVELOP AND IMPLEMENT A C-LEVEL TALENT ATTRACTION INITIATIVE.

To maintain a vibrant and dynamic life sciences industry cluster, Utah should develop an initiative for the attraction of C-level life-science talent to Utah. The infusion of external industry leadership provides new blood and fresh thinking to local problems. This strategy may build upon the success of the BioDevice and BioPharma research talent attraction strategies of the Utah Science Technology and Research (USTAR) initiative. Key participants would include the Economic Development Corporation of Utah and the Governor's Office of Economic Development.

Other states and regions have been active in this area. For instance, in the early 1990s, when Maryland was first advancing the development of a commercial biotechnology industry, that state used grant programs to assist both existing companies expanding in the state for the relocation expenses of senior management as well as emerging biotechnology companies needing to strengthen their management teams. More recently, the Pittsburgh Life Sciences Greenhouse has operated an Executive-in-Residence program since 2002 that has assisted nearly 300 emerging companies with accessing proven C-level leadership. This Executive-in-Residence program provides executive talent to help form companies; subject matter experts to guide companies; executives to run companies; and program managers and directors to help companies grow.

RECOMMENDATION #6: GROW THE NUMBER OF POST-SECONDARY INTERNSHIPS IN THE LIFE SCIENCES.

Internships for college students offer essential skill-specific job training and mentors that can ease the transition into the work world. A 2010 survey of the 884 industry members of the National Association of Colleges and Employers revealed that of those who have an internship or co-op programs, more than 50 percent of interns accept full-time employment with the company for which they interned.[3]

Utah higher education institutions are eager to advance internships for their students, but are reporting difficulties in finding companies willing to take students as interns. The Utah System of Higher Education along with industry representatives should seek to identify the barriers to creating life-science internships. An incentive fund should be established to reduce the cost of creation and participation in life-science student internships. Other states have effectively used incentives to scale up internships. Ohio's Third Frontier Program has an internship program that reimburses up to 50 percent of the intern's wages, or no more than $3,000 for a 12-month period. Ohio targets its internships to a set of high-growth technology industries such as biosciences, information technology, instruments and controls, advanced materials, and advanced energy, among others. Since 2002, more than 3,000 students have participated. More recently, Nebraska enacted InternNE internship grants providing a 40 percent match, up to $3,500 per internship, for up to 10 interns per year (5 at a single location). Up to $1.5 million is allocated for the statewide Nebraska program and it is targeted to a certain set of eligible businesses.

The identification of best practices in internship models and development of strategies to grow internship opportunities should be a key component of the STEM education activities described in recommendation #4.

[3] See web site for National Association of Colleges and Employers

Ensure Access to Capital at All Stage of Life-Science Firm Development

RECOMMENDATION #7: SUPPORT COMMERCIALIZATION AND PROOF-OF-CONCEPT PROJECTS.

Proof-of-concept (PoC)/commercialization funding refers to funds needed to do the additional prototype development, clinical research, and testing and development needed to prove that a technology has commercial potential. Such funding is usually provided in the form of a grant that does not require any repayment. Such funding is often needed to commercialize university-owned as well as industry-owned IP at the highest value—and sometimes to license it at all—as such technology usually is at an early stage of development and requires additional studies, sometimes involving animal trials, or in the case of engineering discoveries, a working prototype, before it can be shown to have commercial value. It also is often necessary to surround the original discovery with additional patents and protections. Such activities are almost never fundable through conventional peer-reviewed federal programs and, if they are to take place at all, must be separately funded under a different set of criteria focused mainly on economic development. Companies seeking to develop a product or process also often require funding for PoC activities.

Thirty-three states reported offering PoC funding in 2008. About half of these programs fund university principal investorgators and/or for-profit companies. Ten or slightly less than a third of the programs fund university principal investigators only in an active university/industry partnership, and eight fund for-profit companies only in an active industry/university partnership. Seven programs provide funding to university technology transfer programs.

One of the longest standing efforts by the Georgia Research Alliance demonstrates the potential impact these proof-of-concept centers can have. Since its launch in 2002, the results of GRA's VentureLab program have been outstanding. A total of $19 million of state funds have been used since 2002, resulting in the formation of 108 active companies, $460 million of additional funds attracted, and over 500 jobs created.

In 2010, USTAR used funding obtained through the American Recovery and Reconstruction Act (stimulus funds) to support PoC projects at Utah universities. In 2011, GOED administers a Technology Commercialization Innovation Program, which provides matching grants of $40,000 that can be used to support commercialization activities. The grants are awarded on a competitive basis to university researchers and/or companies that have licensed technology from a Utah university that they plan to commercialize.

From discussions with biosciences industry, Battelle learned that the size of the TCIP grants limit the program's usefulness for life-science companies given the resources required to develop and test new products. It is recommended that the state consider expanding this program to allow for follow-on and/or larger awards.

RECOMMENDATION #8: PROMOTE THE AVAILABILITY OF VENTURE CAPITAL FOR LIFE SCIENCES INDUSTRY IN UTAH ACROSS ALL STAGES OF VENTURE INVESTMENT.

From Battelle's interviews with life-science entrepreneurs and CEOs of start-up companies, it was reported that it is very difficult to obtain formal venture capital in Utah. There are few locally-based venture funds, particularly funds available for investment in life-science companies, and it is difficult to attract capital from out-of-state without a local partner.

In the past, the Utah Fund of Funds has had a strong track record of success in attracting qualified venture capital funds to consider investments in Utah-based companies. The Fund has invested $120 million in 28 venture funds, 7 of which are Utah-based. The Fund uses an innovative contingency tax credit mechanism to raise capital, and given its strong performance over the years, no tax credits have been used—so there has been no cost to state government. As reported in its 2010 annual report, 42 Utah companies have received $277 million of venture investments from venture capital funds involved in the Utah Fund of Funds program. These investments have created an estimated 1,200 new Utah jobs and have had a multiplier impact of an additional 4,100 Utah jobs. The average salary of these jobs created stands at $71,000, nearly twice the Utah average.

The Utah Fund of Funds is currently considering ways to advance additional investments in qualified venture capital funds to support new and emerging technology companies in Utah. These efforts are strongly needed and should be encouraged. The guidance from the life sciences industry interviews is that strong consideration should be given to attracting qualified venture funds that target life sciences companies.

A particular need in Utah that would be difficult for the Utah Fund of Funds to address is for seed capital funding of life sciences ventures. As noted earlier, Utah lags behind the U.S. average for seed and early stage investments in life sciences, though not in overall venture capital. This is not surprising since new start-up ventures in the life sciences stand quite distinct from other technology areas, such as information technology, in its product development process, regulatory requirements, and integration with existing life-science companies and the health care delivery system. Many states and regions have put in place dedicated life-science seed funds (e.g., Pennsylvania's regional Life Sciences Greenhouse Seed Funds, Indiana's BioCrossroads' Life-Science Seed Fund, and the BioGenerator Seed Fund in St. Louis).

To ensure a pipeline of such high-growth potential emerging technology companies, it is critical for Utah to have in place one or more seed funds that can move a business from concept to launch. Seed funds make equity or near-equity investments in early-stage companies, usually up to approximately $2 million. A number of states have used state dollars to create such investment funds. The Oklahoma Seed Capital Fund (OSCF), for example, is a state-appropriated investment fund that makes concept, seed and start-up equity investments in Oklahoma businesses. The fund makes concept investments, typically in the range of $50,000 to $200,000 and seed investments, typically less than $500,000. Co-investors are required for both types of financing. The funds can be used to develop intellectual property, complete market assessments, implement business operations, and recruit key members of the management team. The OSCF is administered by i2E, Oklahoma's statewide technology commercialization organization. In addition to making investments, i2E

provides comprehensive in-depth support to entrepreneurs, including helping them to become investment grade.

Utah has a constitutional prohibition against investing directly in a private company. A constitutional change would likely be required to allow the state to create a publicly-funded seed fund. This is a change that might be considered in light of Utah's desire to grow its technology clusters, and past precedent with the previous Centers of Excellence and current TCIP efforts. An alternative would be to encourage private investment in seed or venture funds or in companies directly by offering a tax incentive—but these are not as an efficient use of state resources as direct state investments since there is a transaction cost to converting tax credits to investment funds.

RECOMMENDATION #9: SUSTAIN THE LIFE SCIENCE TAX CREDIT

Tax incentives are a well tested and widely used approach for advancing life sciences industry development across the nation. In Utah, the Governor's Office of Economic Development offers three tax credits for eligible life-science and technology companies. These tax credits are aimed at life-science companies that are creating revenue producing new products or services or investors in emerging life sciences companies in the state, and so provide sources of capital to continue to grow the life-science business in Utah.

The New State Revenues Policy credit is particularly innovative in offering life-science companies generating sales from new product or service development projects to receive a refundable tax credit associated with the state revenues generated by that project for its first three years. The state revenues considered are broad-based, including corporate or partnership income tax, wage withholding tax and the state portion of sales tax. This is a powerful incentive for growing, innovative life-science companies to recoup investment for its new product development activities. It has a key feature of being performance based in rewarding those life-science companies generating sales and state revenues from successful new projects. By being refundable this credit also provides a tangible economic benefit for those emerging life-science companies that may not yet be generating an overall business profit since they can still receive a benefit from withholding tax and the state portion of sales tax generated.

The life-science investor tax credits includes a nonrefundable tax credit of up to 35 percent of the amount of investment issued over three years and a nonrefundable tax credit of up to 5 percent of the capital gains from the sale of a qualifying investment. These life-science investor tax credits are targeted to companies capitalized at under $2.5 million and having at least 50 percent of its employees in the State of Utah. By providing funding at the front end of the investment and then the resulting capital gain, this investor tax credit provides a broad-based incentive to invest.

The power of tax credits is their predictability, so that businesses and their investors can plan for its availability. It is important that Utah sustain its efforts in its life sciences and technology tax credits to maximize their effectiveness.

Significantly Increase Collaboration Between University Life Sciences Researchers and Utah Life Sciences Companies

RECOMMENDATION #10: FOSTER GREATER INDUSTRY AND UNIVERSITY COLLABORATION IN APPLIED RESEARCH.

Industry and university collaboration in applied research is a critical means for tapping the research capabilities of universities and achieving commercial success. Often industry needs university expertise to test and develop prototypes using existing company intellectual property. In other cases, industry can identify technology solutions needed to address specific market needs, but require university expertise in how to solve the technology need.

The most common and, in Battelle's experience, one of the most effective means of fostering greater university and industry interaction is to provide matching grants for research partnerships. Such programs help build relationships between academic researchers and companies and provide support for activities that may lead to investments of private capital and commercialization of new technologies.

As of 2008, 28 states had matching grant programs that provide an incentive for firms to support research projects at local research institutions.[5] It is important to note that these matching grant programs provide funding only to public universities, but are directed by the requirements set out by the industry partner providing matching support. Most of these programs solicit applications on a competitive basis and make awards to projects that are both technically sound and likely to have a positive economic development impact. All of the programs require that the company shares the cost of the research project, which is conducted by faculty and students on behalf of the company. The level of cost share can vary. Some programs vary the matching requirement based on the size of the company.

Along with a standard matching grant program for industry sponsored applied research projects at public universities, there was strong support in the industry focus group discussions to also have matching grants available to companies receiving federal Small Business Innovation Research (SBIR)/Small Business Technology Transfer Research (STTR) grants to fill the gaps in federal funding between Phase I and Phase II with university research support. This would be a natural fit for those companies receiving STTR funding, which already have in place university research and development partners. For those companies receiving more traditional SBIRs, which do not have in place explicit university research and development partners, it would be beneficial to be able to tap university resources for testing and prototype assistance in going from Phase I to Phase II.

A leading state in the use of matching funds for SBIR/STTR awards has been Kentucky, which matches both phases of the federal program: up to $100,000 for Phase 1 federal awards and up to $500,000 per year (for up to two years) for Phase 2 federal awards. The Kentucky Science and Technology Corporation, which manages the SBIR/STTR matching program, reports that 117 companies have been assisted, with a leverage of $3.4 in federal funding for every $2 in state funding. In addition, a number of out of state companies with SBIR awards have relocated to Kentucky to participate in the program.

RECOMMENDATION #11: PROMOTE THE ECONOMIC DEVELOPMENT MISSION OF UNIVERSITY TECHNOLOGY TRANSFER AND COMMERCIALIZATION.

Utah's universities place a high priority on technology transfer and commercialization. Across many performance measures of technology transfer and commercialization, Utah's universities stand out among its peers nationally. At the same time, Utah's universities have taken steps in the past five years to restructure their technology transfer and commercialization activities and to encourage and support faculty seeking to commercialize their research findings.

- The U of U reorganized its commercialization efforts in 2005 creating the position of Vice-President for Technology Venture Development who oversees the office that manages the university's intellectual property as well as all commercialization activities on campus. The U of U has spun off 132 start-up companies since 2005 and in both 2009 and 2010 was the number one university in the country in terms of spinning-off university-based start-up companies.
- USU created an Office of Commercialization and Regional Development, which brings together all of the university's commercialization activities including outreach to regional campuses. The office includes Commercial Enterprises, a one-stop shop for industry partnerships and IP development.
- BYU's Technology Transfer Office's mission is to commercialize technology and technical software developed at the university. BYU also has a separate Creative Works Office that seeks to take advantage of commercial applications in areas of instructional materials, software and creative works such as art, music and other media. BYU ranked among the top 10 universities in spinning-off university-based start-up companies in 2010.

Still, there is continued need for improvement in how Utah universities work with industry. As noted previously, companies consistently reported in interviews with the Battelle project team that it is often difficult to work with universities on sponsored research projects and to license technologies due to the terms and conditions imposed by the universities. This issue was further highlighted in the industry strategy focus group meeting held inJanuary.

This issue goes to the heart of whether Utah universities can be strong partners in working with Utah business in advancing innovation and the state's economic development. This issue is also not unique to Utah and its universities. Across the nation, there is a strong concern and focus to advance predictable and streamlined university technology transfer and commercialization processes in which industry can take ownership of intellectual property from sponsored research with universities and for licensing technologies. For instance, the University of Minnesota allows a company sponsoring research at the university to pre-pay a fee and receive an exclusive worldwide license at a set royalty rate. Similarly, the University of North Carolina has put in place the Carolina Express License, which offers a "standard" license agreement for university developed technology to ease the burden and time requirements on negotiations, involving reimbursement of patent expenses and standard royalty fees.

One approach to improve relations would be to form an industry/university panel charged with preparing a White Paper that reviews in more detail the issues surrounding the process as well as the terms and conditions involved in licensing and research contracts at Utah's public universities. The focus of this panel would be to

promote efforts to harmonize terms and conditions, with an effort towards more simplification, while also seeking to streamline the process so that it can work more at the speed of business. The panel should also establish performance benchmarks and on-going oversight to ensure the continual improvement needed to advance more business friendly contracting and licensing with universities, which is critical to enable industry-university partnerships.

RECOMMENDATION #12: FOSTER GREATER INDUSTRY AND UNIVERSITY INTERACTIONS AND PARTNERING.

Complementing the changes in policies and processes in working with existing industry is the need to raise the awareness of current university and industry research efforts and interests. Interviews with researchers and industry CEOs suggested that Utah would benefit from increased communication across disciplines and institutions, as well as between universities and industry.

Utah is fortunate to have a base of well established, globally competitive life-science companies, many of which would have the resources to more easily introduce new products or services into the market than universities through new start-ups. However, most life-science business executives indicated in interviews with the Battelle project team that they were unaware of current research that might be under way at the universities in areas of interest to their firm or of potential technologies that might be available for licensing. Similarly, university researchers would benefit from learning about specific market needs and ongoing research and development efforts by industry.

This strategy identifies four life-science strategic opportunity areas that offer the greatest potential for growing Utah's life sciences industry cluster. To capitalize on these opportunities and realize the economic development potential of developing these areas, researchers from Utah's colleges and universities, medical centers, and industry should get to know one another and begin to find ways to collaborate.

One mechanism that can be used to foster such relationships is the development of technical networks or scientific interest groups composed of industry, academia, and resource providers. Battelle recommends that Utah create technical networks focused on medical devices, drug development, personalized medicine, and nutritional supplements. Typically these efforts are housed in the life sciences industry association advancing this sector, but they can also be driven and/or supported by the state economic development cluster lead for the life sciences.

Battelle also suggests that broader technology partnering events be held to showcase university-developed IP that is available for commercialization, as well as highlight innovative industry capabilities. Ideally, this effort would involve multiple approaches. These could be in-person events that would feature presentations by faculty and industry as well as provide opportunities for one-on-one meetings between researchers and industry representatives. These meeting could also feature networking and poster sessions as well as tours of facilities to make businesses and university faculty more aware of the facilities, equipment and expertise available in Utah.

An excellent example is the Tech Tuesday networking events presented by the Technology Commercialization Office (TCO) at the University of Utah. These special events feature guest speakers, local inventors, and entrepreneurs. More of these types of engagements are needed, and typically these are activities supported by

the Utah Technology Council, the state's life sciences industry association, in partnership with the state's universities.

Another approach Battelle recommends to make companies more aware of university research activities is to create a talent bridge between university research programs and industry through access to graduate students and post-doctoral fellows through internships and fellowships. Both Connecticut and the North Carolina Biotechnology Center advance these types of collaborations.

Advocate for and Market Utah's Life-Science Assets

RECOMMENDATION #13: CONTINUE EFFORTS TO ATTRACT NATIONAL AND INTERNATIONAL CONFERENCES TO UTAH AND MAINTAIN UTAH'S PRESENCE AT KEY NATIONAL LIFE SCIENCES CONFERENCES HELD OUTSIDE OF THE STATE.

It is important that Utah raise its profile nationally in the life sciences. One excellent mechanism is the use of conferences that bring leading life-science researchers and business people to Utah to provide an opportunity to make them aware of the state's life-science assets and resources. An excellent example is the National Summit on Personalized Health Care that has been held annually for the past 4 years in Deer Valley, Utah. This conference brings together top leaders from throughout the world who are working to develop a roadmap that will develop and integrate individualized/personalized health care approaches, technologies and practices into patient care.

Conferences should be targeted that would highlight Utah's life-science technology opportunity areas. For example, given the large number of international natural products companies whose corporate headquarters are located in Utah, the state should actively seek to become a major hub for natural products conventions and conferences. This should span conferences of individual firms as well as broader industry-wide conferences involving university faculty active in this area from Utah and across the U.S. There might also be efforts to tap the growing emphasis on personal nutritional plan strategies, and Utah could host a national conference and forums on this effort.

More generally, Salt Lake City should actively pursue small and medium life-science conferences. This can include areas of focus outside of Utah's strengths to focus on topics of importance for advancing Utah's life sciences industry. For instance, Utah has had a hard time attracting persons with expertise in quality assurance and regulatory affairs in the life sciences industry; thus, Utah should actively seek and host national conferences focused on these disciplines to expose experts in these field to Utah, and partner with higher education to develop degree and certificate programs that meet the local talent need in these two areas.

Ways to advance this action would be to survey existing life-science companies and their employees to identify national trade association memberships they maintain and then launch a recruiting campaign to attract their national conferences to Utah. While it is important that this action tap the broad life sciences community in

Utah, there is a need to identify a primary contact (individual or organization) that will organize the efforts to identify, attract, host and retain life-science national/international conferences and conventions.

While Utah targets the small to mid-sized life-science conferences, it is also important that Utah maintain a presence at the larger national and global life-science conferences held outside of the state. Of particular importance is maintaining a Utah presence at the annual BIO conference, which is a key meeting place of the life sciences industry from across the globe.

RECOMMENDATION #14: CONTINUE EFFORTS TO PROJECT AN IMAGE OF UTAH AS A DIVERSE AND WELCOMING STATE.

An issue that was raised by life-science business leaders in interviews was that it is often difficult to recruit workers to Utah because of the image that many people have of Utah; that the state lacks diversity and is dominated by one culture, that of the Mormon Church. A Quality of Life survey conducted by the Utah Foundation asked Utahans about the quality of life factors that were important to them and how they rated the state on each factor. A social factor that ranked high in importance and lower in quality was whether people were accepting of differences, meaning that people highly valued this factor but felt that people were not as accepting as they would like. This is an area of concern in a state like Utah where there is a large racial majority, as well as a religious majority.

Utah's minority groups are growing, however, and the state is becoming more diverse. But while the social fabric may be changing, perceptions usually lag reality. As a result, efforts are needed to both boost tolerance and to promote Utah's image as a diverse and welcoming state. Initiatives are under way to do this. The Alliance for Unity seeks "to foster a more unified community in which all Utahans are included and valued, regardless of affiliations or differences."[18] The UTC has a campaign, "Why Utah" that includes videos that feature people from diverse backgrounds who have relocated to Utah talking about their positive experiences. Such efforts should be continued and expanded.

Among the ideas for broadening these efforts would be to work with LDS and other religious denominations to encourage their Utah-based congregations to be accepting of differences. It would also be helpful to engage non-LDS employees directly in recruiting new employees from out of state. These engagements could include opportunities to meet and greet and provide personal testimonies of day-to-day-life in Utah to dispel misconceptions. There should also be a concerted effort in company literature, websites and recruiting materials to tap into the "Why Utah" effort emphasizing Utah's natural beauty and resources (outdoor life, recreational assets, etc.), the state's strong, well-educated workforce and talent pipeline and the great urban life style of downtown SLC with easy access to the great outdoors life Utah offers.

RECOMMENDATION #15: PROMOTE ACTIVE OUTREACH MARKETING OF UTAH IN THE LIFE SCIENCES.

Utah's life-science community should work to develop a common theme that can be incorporated in state marketing materials as well as those of the various organizations that are committed to growing the state's life sciences sector. An active earned media campaign of magazine and newspaper articles and television stories should be considered following release of this strategy. Having articles appear in newspapers and magazines nationwide describing Utah's life sciences industry can play a key role in changing the state's image. The

placement of such articles, however, will require an active public relations outreach to key publications and the active development of news stories.

An internal education campaign also could be initiated to increase Utah policymakers', legislators' and residents' knowledge and understanding of the life sciences; the role the industry plays in Utah's economic future; the opportunities they provide for them and their children; and the role new discoveries and inventions will play in their lives. It will be particularly important to brief legislators so that they understand the impact that state investments in education and R&D can have on their constituents. The internal campaign should be aligned with the branding and marketing campaign, but it will require a distinct set of activities. These could include public service announcements, a life-science ambassador program to reach schools and local civic organizations, and regular monthly and quarterly events. It is also important to engage state legislators through specific forums and outreach activities involving the life-science community.

RECOMMENDATION #16: ENSURE CAPACITY WITHIN STATE GOVERNMENT TO ADVANCE THE INTERESTS AND ADDRESS THE NEEDS OF THE LIFE SCIENCES.

The life sciences industry face very distinct and challenging development issues even from other technology areas, such as information technology, in its product development process, regulatory requirements, specialized talent needs and interactions with universities and the health care delivery system. If Utah is to accelerate the growth and competitiveness of its life sciences industry cluster, it needs to recognize these specialized needs of life sciences industry development and ensure a strong voice focused solely on the life science industry within state government to best align and coordinate state development approaches.

One approach widely used by other states that are actively pursuing specific industry cluster developments is to have a dedicated life sciences industry cluster staff person within the state's economic development agency. Utah's current structure does not have a person whose sole responsibility is life sciences industry cluster development. With the dedicated focus of a life sciences industry cluster staff person, Utah would benefit from a focused resource able to work consistently and uninterrupted with the life sciences industry, while the industry will have a "go to" person to address specific issues and opportunities.

Creation of this position has the potential to align all stakeholders including GOED, USTAR, the life sciences industry association/UTC, Chambers of Commerce, higher education, and education to strengthen this significant and growing economic driver for the State of Utah.

RECOMMENDATION #17: ADVOCATE FOR UTAH'S LIFE SCIENCES INDUSTRY.

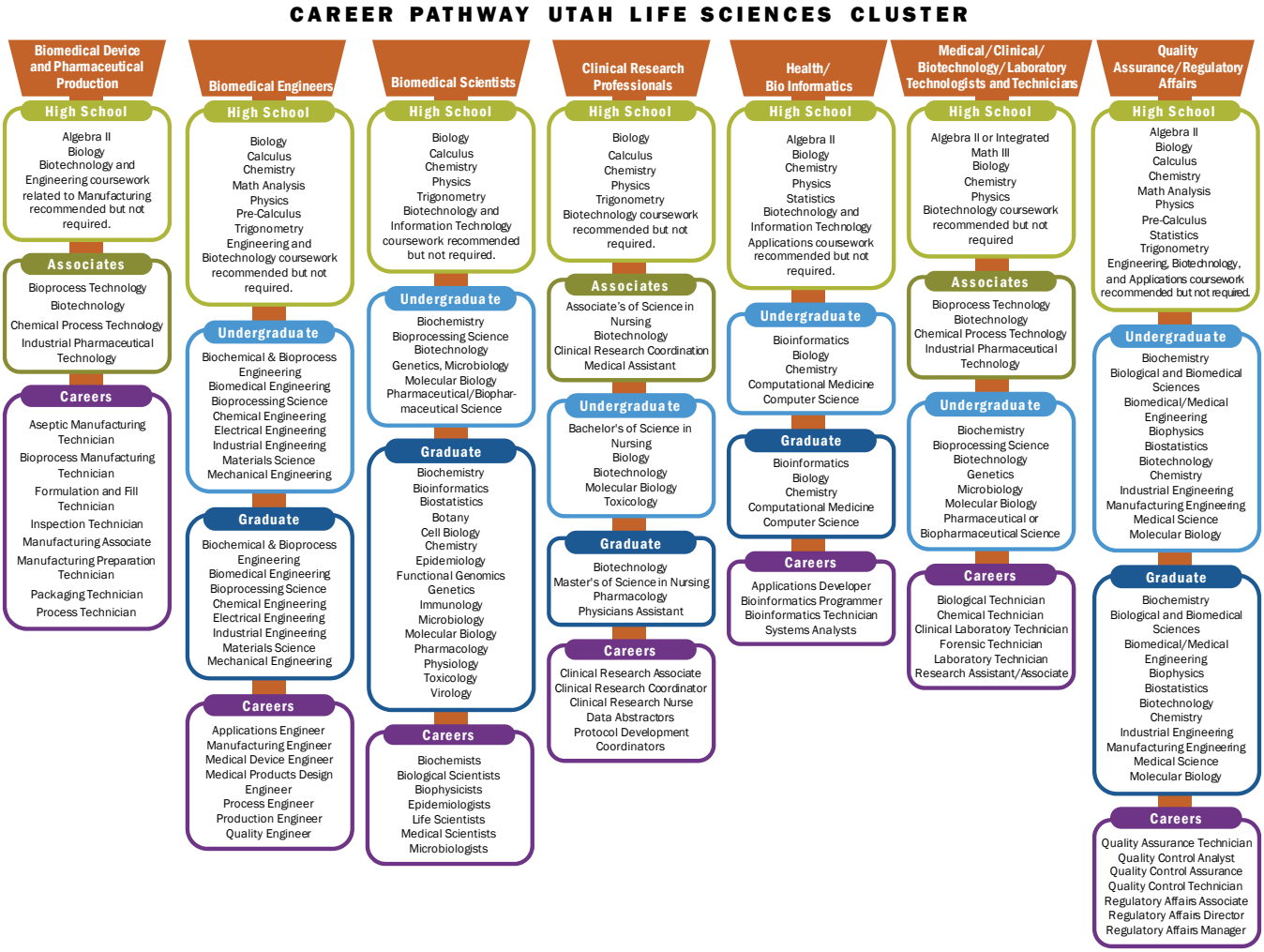
Interviews with industry business executives repeatedly emphasized the need to engage, as a state, in the national policy debates surrounding FDA regulatory reform. Specific issues currently in the current spotlight include the proposed tax on medical devices however; ever-changing national policies can have huge positive or negative impacts on this sector. Without a dedicated position to monitor and help influence national policy and align state efforts, Utah will remain a silent voice and industry may suffer.

Utah Technology Council and other industry organizations should lead the effort to join forces with other states to further emphasize the need to engage, as a state, in the national policy debates surrounding FDA

regulatory reform. Specific issues currently in the spotlight include the proposed tax on medical devices. However; any of the many changing national policies can have a huge positive or negative impact on this sector . Without a dedicated effort to monitor and help influence national policy and align state efforts, Utah will remain a silent voice.

Appendix A: Utah Life Sciences Career Pathways

The following lays out an initial set of career pathways for occupations in the life sciences, identifying the education requirements and career opportunities. It was developed by first searching for national models on career pathways from a variety of national organizations, including the American Medical Technologists (AMT); the American Society for Quality (ASQ); the Association fo Clinical Research Professionals; Bio-Link, the National Advanced Technological Education (ATE) Center of Excellence for Biotechnology and Life Sciences; the National Association of State Directors for Career Technical Education Consortium; and the North Carolina Biotechnology Center. It was further refined by comments from industry and educators. This initial depiction of life sciences career pathways is provided as a starting point for Utah to integrate linkages across its state to better develop and create link programatics offerings to workforce opportunities. As the Life Sciences UCAP is implemented, this initial set of life sciences career pathways will be enhanced and refined.



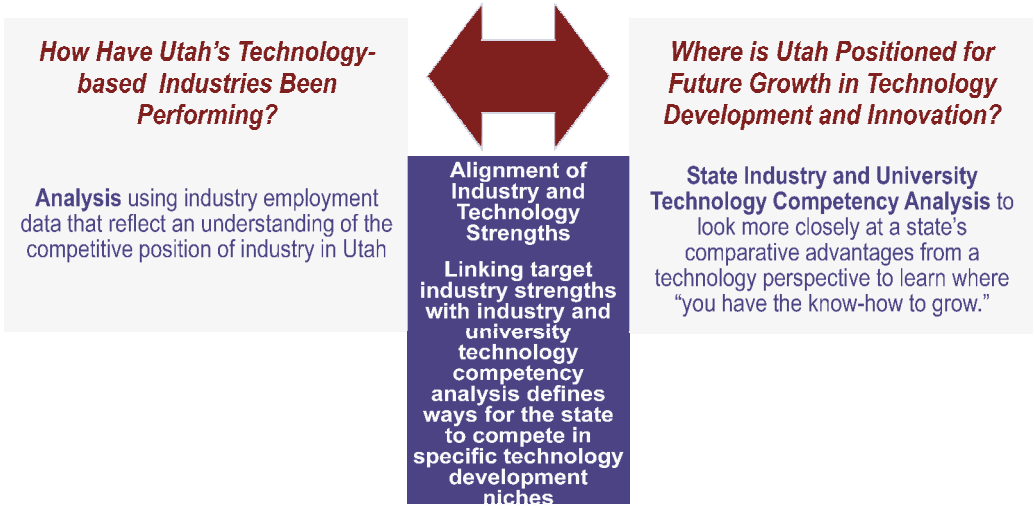
Appendix B: Detailed Life Sciences Industry Cluster Profile

Battelle examined the life sciences industry cluster in more depth to determine how it is positioned for technology-based growth. The analysis considered the alignment of two key factors:

- Detailed industry-level analysis of specific product and service focus areas found in Utah to identify the drivers of the state's life sciences industry sector. [6]
- Technology competencies found within the life sciences industry cluster**.** As mentioned earlier, technology competencies represent focused areas of "know how" where there is demonstrated critical mass in Utah.
    - The starting point for defining these technology competencies is "Innovation Themes" identified from the cluster analysis of patents and publications in Utah from 2006 through June of 2011. Battelle then validated the extent of these Innovation Themes based on both industry and scholarly activities by considering:
    - Focus of scholarly excellence in Utah based on performance of research universities in peer-reviewed publications analysis.
    - Identified research centers and major research activities found across Utah's research universities, based on Battelle's interviews and review of major grants and web sites.
    - Level of technology deployment as suggested by value-added per employee for detailed industry segments.
    - Presence of innovative, emerging technology firms, based on firms receiving venture capital funding between 2006 and 2011 (2nd quarter).

By linking core technology competencies to specific industry strengths within an overall industry cluster, it is possible to define not only where a state has demonstrated the ability to advance industry development but where it has the know-how to continue to fuel innovation and further distinct areas of growth. This approach is depicted in Figure B1 below.

Figure B-1: Alignment of Detailed Industry Strengths and the Presence of Core Technology Competencies



Findings

The life sciences industry cluster is both specialized and growing in Utah. In 2010, it stood at 22,983 jobs, which translates into an 82 percent higher employment concentration in Utah than the nation. Employment in the life sciences industry also grew a healthy 25.8 percent over the 2001 to 2010 period, which included a 9.2 percent increase in jobs from 2007 to 2010, a period which includes the deep recession years of 2008 and 2009 and the nascent recovery that began in 2010.

The life sciences industry is composed of four subsectors including Medical Devices and Equipment; Drugs and Pharmaceuticals; Research, Testing, and Medical Labs; and Biomedical Distribution. It is important to note that the life sciences industry is closely related to but not the same as healthcare industry, which provides direct clinical services. The breadth of Utah's life sciences industry cluster comes across, since all of these subsectors of the life sciences are specialized and growing rapidly in Utah.

Detailed Industry Strengths

At the detailed industry level, there are 11 industries within the life sciences industry cluster with 500 or more jobs in 2010—all are either specialized and/or growing in employment.

Six of the 11 detailed life sciences industries are both specialized and growing, including:

- **Pharmaceutical Preparation Manufacturing**, with 3,892 jobs in 2010, a 105 percent higher concentration in Utah than the nation and growing in jobs by 25.6 percent from 2001 to 2010.
- **Medical Laboratories**, with 3,237 jobs in 2010, a 127 percent higher level of concentration in Utah than the nation and growing in jobs by 91.0 percent from 2001 to 2010.
- **Drugs Wholesalers**, with 2,194 jobs in 2010, a 53 percent higher level of concentration in Utah than the nation, and increasing in jobs by 28.6 percent from 2001 to 2010.

- **Irradiation Apparatus Manufacturing**, with 1,270 jobs in 2010, a 10.7 times higher level of concentration in Utah than the U.S. and increasing in jobs by 21.9 percent from 2001 to 2010.
- **Medicinal and Botanical Manufacturing**, with 760 jobs in 2010, a 330 percent higher level of concentration than the nation, and increasing in jobs by 7.8 percent from 2001 to 2010.
- **Dental Equipment and Supplies Manufacturing**, with 684 jobs in 2010, a 394 percent higher level of concentration than the nation, and increasing in jobs by 11.6 percent from 2001 to 2010.

Four of the 11 detailed life sciences industries are growing in jobs, but not yet specialized in the concentration of industry employment in Utah.

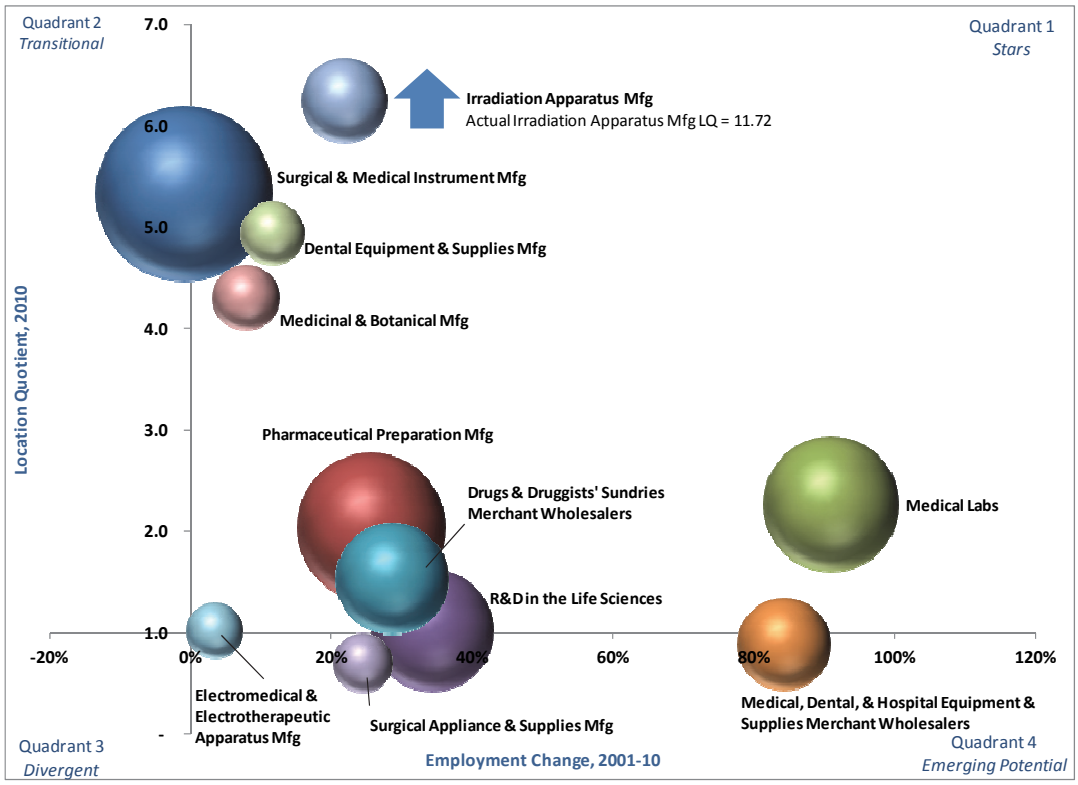
- **Life Sciences Commercial Research & Development**, with 2,620 jobs in 2010, increasing in jobs by 34.3 percent from 2001 to 2010, but only equal to the U.S. level of employment concentration.
- **Medical, Dental, and Hospital Equipment and Supplies Wholesalers**, with 1,489 jobs in 2010, increasing in employment by 84.3 percent from 2001 to 2010, but 11 percent lower in concentration than the nation.
- **Surgical Appliance and Supplies Manufacturing**, with 611 jobs in 2010, increasing in jobs by 24.4 percent from 2001 to 2010, but still 30 percent less concentrated in Utah than the nation.
- **Electromedical and Electrotherapeutic Apparatus Manufacturing**, with 540 jobs in 2010, increasing in jobs by 3.4 percent from 2001 to 2010, but only equal to the U.S. level of employment concentration.

One of the 12 detailed life sciences industries is highly specialized, but not growing in jobs:

- **Surgical and Medical Instrument Manufacturing** with 5,490 jobs in 2010, a 434 percent higher level of concentration in Utah than the nation, but a decline in jobs of 1.0 percent from 2001 to 2010.

It is important to note that natural products and dietary supplement firms fall in various industry classifications including pharmaceuticals, biomedical distribution industries, and other food and beverage categories.

Figure B-2: Detailed Utah Life Sciences Industries: Employment, Growth, & Specialization Trends, 2001–10



Note: Includes only those detailed Life Sciences industries with at least 500 jobs in Utah in 2010.

Linkage to Core Technology Competencies

The cluster analysis of patents and publications identified 17 Innovation Themes in the life sciences industry in Utah, which group into four categories:

- Medical Devices
- Disease Research, Drugs and Pharmaceutical Related
- Basic Biological Research Related
- Natural Products and Dietary Supplements.

Table B-1: Innovation Themes Within the Life Sciences Industry Cluster

Breadth of Patent and Publications Clusters Number of patent and publication records in cluster groupings from 2006 to 2011	**Presence of Institutional Research Centers and Other Specialized Strengths**	**Publications** ***High Share/High Quality:*** Greater than 1.5% of U.S. pubs and greater than 40% higher citation impact than U.S. average ***High Share Only:*** Greater than 2% of U.S. pubs ***High Quality Only:*** Greater than 50% higher citation impact than U.S. average	**Productivity** Relative level of 2009 value added per employee for detailed industry sector in Utah compared to U.S. average	**Presence of Detailed Industry Strengths** ***Current Industry Strength*:** both specialized (greater than 20% higher industry employment concentration in 2010) and growing in jobs from 2001 to 2010) ***Emerging Industry Strength*:** Growing in jobs from 2001 to 2010, but not specialized ***Specialized Industry Strength*:** Specialized, but lost jobs from 2001 to 2010	**Presence of Venture-backed Companies** Number of companies receiving venture funding from 2006 to 2011
MEDICAL DEVICE					
Surgical Instruments, Equipment and Devices: 1310 Cardiovascular & Pulmonary Diseases and Conditions: 805 Medical Imaging: 325 Musculoskeletal Implants and Devices: 268 Ion Channel Research: 165	U of U Cardiovascular Research and Training Institute (cardiac electrophysiology + vascular physiology) U of U Bioengineering Department, including focus on cardiovascular, neural engineering, and novel devices (Utah BioDesign)	***High Share/High Quality:*** Biomaterials: Imaging Sciences Cardiovascular Systems Rehabilitation ***High Share Only:*** Orthopedics Biomedical Engineering	Surgical Appliance and Supplies Manufacturing: 87% Dental Equipment and Supplies: 83% Irradiation Apparatus Manufacturing: 75% Surgical and Medical Instrument Manufacturing: 75% Electromedical and Electrotherapeutic Apparatus Manufacturing: 62%	***Current Strengths:*** Irradiation Apparatus Manufacturing Dental Equipment and Supplies Manufacturing ***Emerging Strengths:*** Surgical Appliance and Supplies Manufacturing Electromedical and Electro-therapeutic Apparatus Manufacturing ***Specialized Industries:*** Surgical and Medical Instrument Manufacturing	9 VC backed firms in Medical Devices 2 VC backed firms in Medical Imaging
DISEASE RESEARCH AND PHARMACEUTICALS					
Drug Development & Discovery: 794 Cancer Research and Treatments: 1,143 Neurosciences: 1,226 Infectious Diseases, Pathogens and Immunology: 727 Reproductive Medicine: 482 Diabetes: 294 Transplantation and Stem Cell Therapies: 226 Ophthalmology: 180	U of U College of Pharmacy among national leaders in medicinal chemistry, pharmaceutics and pharmaceutical chemistry Eccles Institute of Human Genetics Huntsman Cancer Institute, with close ties to medicinal chemistry and human genetics BYU Cancer Research Center U of U Molecular Medicine Utah State University's Center for Integrated Biosystems with focused research efforts in flu vaccine production, bioprocessing technologies and reproductive immunology.	***High Share/High Quality:*** Pharmacology Toxicology Transplantation Urology & Nephrology ***High Share Only:*** Ophthalmology Clinical Neurology Obstetrics & Gynecology Neurosciences Physiology Rheumatology ***High Quality Only:*** Geriatrics Peripheral Vascular Disease Endocrinology & Metabolism	Life sciences Commercial Research & Development: 79% Pharmaceutical Preparation Manufacturing: 57% Medicinal and Botanical Manufacturing: 57%	***Current Strengths:*** Pharmaceutical Preparation Manufacturing Drugs Wholesalers Medicinal and Botanical Manufacturing ***Emerging Strengths:*** Life Sciences Commercial Research & Development	4 VC backed firms in Medical Therapeutics

Continued on next page

BASIC BIOTECHNOLOGY RESEARCH					
Genomics and Biologics: 1,269 Molecular Genetics and Cell Biology: 386	Department of Pathology and ARUP Laboratories, a national clinical and anatomic pathology reference laboratory Huntsman Cancer Center Molecular Medicine CTSA with key focus on biomedical informatics and pilot projects	***High Share/High Quality:*** Human Genetics & Hereditary Development Biology Med Lab Tech ***High Share Only:*** Biochemistry and Molecular Biology: ***High Quality Only:*** Cell Biology:	Medical Laboratories: 88% Life sciences Commercial Research & Development: 79%	***Current Strengths:*** Medical Laboratories ***Emerging Strengths:*** Life Sciences Commercial Research & Development	5 VC backed firms in Biotechnology-related Diagnostics
NATURAL PRODUCTS AND DIETARY SUPPLEMENTS					
209	USU Applied Nutrition Research Program	***High Quality Only:*** Nutrition and Dietetics:	Medicinal and Botanical Manufacturing: 57%	***Current Strengths:*** Medicinal and Botanical Manufacturing	

Possible Opportunities for Future Growth

From interviews with industry executives and university leadership as well as ongoing input from the life sciences industry cluster acceleration strategy steering committee supported by the Utah Higher Education System, Battelle suggests several specific niches stand out for Utah in life sciences:

- Novel medical devices
- Molecular diagnostics and personalized medicine
- Molecular medicine, drug discovery, development and delivery
- Natural products and dietary supplements

Novel Medical Devices

A medical device is a product involved in diagnosis, therapy, or surgery for medical purposes. It involves a wide range of products from imaging to monitoring to implants to surgical instruments and equipment. A major revolution is taking place in advanced medical devices involving the introduction of advanced technologies to improve tools for diagnosis and treatment and the development of biological substitutes to restore, maintain, and improve tissue, bone, and organ condition. Some of the leading technologies being adapted for use in innovative medical treatments and diagnostics include microelectronics, imaging, nanotechnology-related biosensors, robotics, and biopolymer materials.

HOW IT BUILDS ON UTAH STRENGTHS

- Utah has a broad medical device industry including strong specializations in Surgical and Medical Instruments, Dental Equipment, and Irradiation Apparatus, and emerging strengths with growing employment in Electromedical and Electrotherapeutic Devices, and Surgical Apparatus and Supplies Manufacturing.
- A number of emerging Utah biomedical companies advancing new therapeutics received venture financing from 2006 through the first quarter of 2011, including:
    - Amedica Corporation, for developing orthopedic devices
    - Catheter Connections, Inc., for developing medical infusion accessory products
    - Coherex Medical, for developing medical devices for addressing structural heart diseases including closure systems that stimulate tissue in-growth and to close left atrial appendage
    - Control Medical Technology, for developing aspirator devices where fluids are aspired through small devices
    - Health Line International, for developing vascular access and infusion therapy products
    - Vital Access Corporation, for developing surgical and interventional technologies for vascular access
    - White Pine Medical, with a focus on cardiovascular, orthopedics and neurostimulation devices
    - Maxtec, Inc., for manufacturing oxygen analyzers and monitors.
- A wide number of Innovation Themes are found in Medical Devices including:
    - Surgical Instruments, Equipment and Devices
    - Musculoskeletal Implants and Devices
    - Cardiovascular and Pulmonary Conditions
    - Medical Imaging
    - Transplantation and Stem Cell Applications
    - Ophthalmology
    - Ion Channel Research

Utah stands out in a wide number of publications fields related to medical devices including: Biomaterials, Transplantation, Cardiac and Cardiovascular Systems, Imaging Sciences, Biophysics, Biomedical Engineering, Orthopedics and Neuroimaging.

Among the many university research centers and focus areas found in Medical Devices are:

- University of Utah Cardiovascular Research and Training Institute, which is focused on electrophysiology seeking to understand how both normal and diseased hearts generate electrical signals and how these signals modulate contraction. Such knowledge provides a basis for more effective treatment of arrhythmias and other disease states that affect ion movements across heart cell membranes.
- University of Utah Bioengineering Department, which brings an active focus on cardiovascular devices, neural engineering and through its Utah BioDesign the advancement of novel devices through close collaborations with surgeons and other clinicians.
- University of Utah Scientific Computing and Imaging Institute, which is a renowned center of excellence with a core focus on biomedicine applications to address new image analysis techniques, visualization of complex and rich scientific data, advancement of computational and numerical methods for scientific computing and development of scientific software environments. SCI is home to the NIH funded Center for Integrative Biomedical Computing (CIBC) which is dedicated to producing open-source software tools for biomedical image-based modeling, biomedical simulation and estimation, and the visualization of biomedical data.
- University of Utah Nano Institute, which is working on biomedical device innovation to improve the performance of implants and promote functional regeneration of tissue, along with work on polymer innovations for gene therapy and enhanced delivery of therapeutics.
- Brigham Young University, with a focused effort on Compliant Mechanisms, which can advance novel biomedical devices through the use of microelectromechanical and nanoelectromechanical systems.

Molecular Diagnostics and Personalized Medicine

The growing knowledge of genomic and proteomic data linked to specific disease states or predisposition is fueling the rise of molecular diagnostics. Molecular diagnostics is not only a new tool for medical diagnosis, it is a gateway to personalized medicine. As we near the end of the first decade of the 21st century, the promise of personalized medicine remains largely ahead of us. Molecular diagnostics are integrally linked with the personalized medicine approach of pharmacogenomics, which considers how genetic variations or differences in gene expression affect the ways in which people respond to drugs. In fact, these personalized medicine approaches to understanding of how genetic variations affect reactions to different drugs can enable diagnostic tests to be established that can guide doctors to make more informed and cost-effective medication decisions for their patients.

HOW IT BUILDS ON UTAH STRENGTHS

- Utah stands out in the strength of its medical testing laboratories, with 3,237 jobs in 2010, a specialization 127 percent higher than the national average, strong growth of 91 percent from 2001 to 2010 which well outpaces national growth for the industry.
- Of particular note for Utah is the presence of ARUP Laboratories, one of the nation's leading clinical and anatomic pathology reference laboratory. ARUP Laboratories was created in 1984 by the University of Utah School of Medicine's Department of Pathology, and has established itself as a role model for bridging the gap between academic medicine and successful business enterprise. Not only does ARUP Laboratories process more than 30,000–35,000 specimens of blood, fluid, and tissue samples are processed each day, it has become a world leader in laboratory research and development having developed more than 400 clinical laboratory tests and improving and validating more than 200 others, but having an extensive publications track record in peer-reviewed journals.
- While in vitro diagnostics does not stand out as a specific industry in Utah, the state is home to Myriad Genetics, one of the nation's leading molecular diagnostic companies with a broad number of diagnostic procedures related to cancer detection and treatment, including for breast, colorectal, melanoma, pancreatic and prostate cancers, along with risks from chemotherapy. Emerging diagnostic companies found in Utah include Sorenson Genomics, focused on verifying human identity and relatedness, and Lineagen, with a diagnostic on the market for autism and ongoing scientific programs in the areas of multiple sclerosis (MS) and chronic obstructive pulmonary disease (COPD).
- A number of emerging Utah biopharmaceutical companies advancing new diagnostics and testing products and services received venture financing from 2006 through the first quarter of 2011, including:
    - Numira Biosciences, LLC, a specialty contract research organization focused on analysis of tissue samples for disease progression, drug efficacy and drug side effects.
    - Lineagen, Inc., focused on molecular diagnostics for autism.
    - Axial Biotechnology, focused on the use of genetics and minimally invasive fusionless devices to diagnosis human spine diseases.
    - BioMicro Systems, Inc., developing micro fluid analysis technologies for genomics, proteomics and diagnostics research
    - Sera Prognostics, providing diagnostics to predict and manage pregnancy complications.
- The Corptech database of technology companies identifies medical diagnostic equipment as a strength in Utah, with 19 firms headquartered or with operating units in Utah, comprising 3 percent of all firms nationally.
- Genomics and biologics stand out as a distinct Innovation Themes based on the cluster analysis of patents and publications. The types of activities include methods for detecting genomic variations;

approaches to genotyping; microarray assays; biomarkers and molecular diagnostics; and population based gene association studies.

- Utah stands out in a number of fields closely associated with molecular diagnostics, including Medical Laboratory Technology and Biochemistry and Molecular Biology
- Among university research centers and focus areas there are several of note in this area of molecular diagnostics and personalized medicine:
    - The University of Utah's Nano Institute is focused on the development of nano-based diagnostics and therapeutics through the application of nanobiosensors for early disease detection, chromatography, and immunoassay applications.
    - The Huntsman Cancer Institute is a National Cancer Institute designated Cancer Center noted for its contributions in identifying the genetic mutations responsible for inherited susceptibility to a number of cancers, including neurofibromatosis, colon cancer, breast cancer, and melanoma. This strength of the Huntsman Cancer Institute is closely tied to the Department of Human Genetics at the University of Utah noted for its model systems work in genetics research involving C. elegans, drosphila, mice, and zebrafish.
    - The NIH funded University of Utah Center for Clinical and Translational Science, represents a collaboration with Intermountain Healthcare, University Health Care, Utah Department of Health and the Salt Lake City Veterans Administration. The Center is building on the university's strengths in genetics and bioinformatics to bring promising bench science into practice.
    - Brigham Young University, which also has faculty research ongoing in molecular diagnostics including:
        - Development of lab-on-a-chip tools to detect and quantify clinically relevant biomolecules
        - Development of new bioarrays for tissue analysis using mass spectroscopy in collaboration with the La Jolla Institute for Molecular Medicine (LJIMM).
    - Utah Population Database of The Church of Jesus Chris of Latter-Day Saints (the Mormon Church) is a rich source of genealogical records on more than 7 million people. UPDB is composed of an extensive set of family histories. It has been linked to the state's cancer registry, inpatient discharge data for all hospitals in Utah and medical records from the enterprise data warehouses of the University of Utah Hospitals and Clinics and from Intermountain Health System, including ICD9 diagnoses, pharmacy data, medical imaging, radiology and pathology reports. So it offers a very powerful tool for epidemiological, public health and health outcomes research. One continued area of development is to associate a biospecimen bank with UPDB to enable it to become an even more valuable resource for genomic analysis.

Molecular Medicine; Drug Discovery, Development and Delivery

With the recent advances in genomics and biotechnology, a new era of molecular medicine is revolutionizing the development of drugs from the traditional trial and error approach to a more predictive and systematic use of detailed information about the operations of cells and molecules to pursue more focused interventions on disease processes. In particular, the use of advances in genomics and proteomics combined with improved disease model systems and computerized or "in silico" high throughput screening is transforming our understanding of the structure and function of genes and proteins and leading to improved ability to identify new potential targets of intervention for diseases. An important use of in silico drug development is assisting in the pharmacological study of drugs to improve drug design for absorption, distribution, metabolism, excretion, and toxicity.

Drug delivery is also being advanced through the use of polymer-based drug delivery systems and nanotechnology. Advances in polymer science have led to the development of several novel drug-delivery systems, including biodegradable polymers that can degrade into non-toxic forms in the body, highly absorbent and responsive hydrogels that can be used as biosensors as well as in wound healing and tissue scaffolding, and novel supramolecular structures able to deliver biologics. Often involved in novel polymers, but also useful in other materials for drug delivery, are advances in nanomaterials. Nanomaterials have a number of functions in drug delivery such as encapsulation to protect the drug and prevent it from reacting with non-targeted tissues during transport, and as functional drug carriers in targeted delivery systems. Nanosized particles have higher rates of diffusion and solubility, the ability to penetrate the blood-brain barrier, lower immune rejection rates, better digestibility, and more precise timed release and thus increased efficacy. The key value of nanotechnology in drug delivery is the potential to make drugs more effective at lower doses, at minimal or no toxicity, and help convert drug candidates that otherwise are poorly soluble in water into viable products.

HOW IT BUILDS ON UTAH STRENGTHS

- In industry development, Utah has performed well across industries comprising the biopharmaceutical sector, including Pharmaceutical preparation manufacturing, Medicinal and botanical manufacturing, and Life-science Commercial R&D.
- A number of emerging Utah biopharmaceutical companies advancing new therapeutics received venture financing from 2006 through the first quarter of 2011, including:
    - Cognetix, focused on pain pharmaceuticals
    - Inflabloc Pharmaceuticals, developing anti-inflammatory therapeutics
    - Prolexys Pharmaceuticals, focusing on cancer and cardiovascular conditions
    - MediProPharma, focusing on central nervous system drugs
    - Q Therapeutics, focusing on central nervous system drugs based on glial progenitor stem cell therapeutics

- A wide number of Innovation Themes emerge in disease research, drug-related basic research and pharmaceutical development found in Utah, based on an analysis of the content of patents and publications, including:
    - Neurosciences
    - Cancer
    - Drug Development and Delivery
    - Infectious Diseases, Pathogens and Immunology
    - Diabetes
    - Molecular Genetics and Cell Biology.
- In scholarly activity Utah stands out in a number of fields based peer-reviewed publications and related citations over the 2005 to 2009 period including: Pharmacology/Pharmacy, Organic Chemistry, Genetics & Heredity Toxicology Biochemistry and Molecular Biology, Neurosciences, Medicinal Chemistry, Cell Biology, Endocrinology and Metabolism
- The University of Utah, as the state's academic medical center, has a number of specific research centers and colleges that stand out in their excellence:
    - The University of Utah College of Pharmacy is one of the top National Institutes of Health funded colleges of pharmacy, nationally recognized in medicinal chemistry, pharmaceutics and pharmaceutical chemistry spanning drug discovery, evaluation, delivery and outcomes research.
    - The Huntsman Cancer Institute is a National Cancer Institute designated Cancer Center noted for its contributions in identifying the genetic mutations responsible for inherited susceptibility to a number of cancers, including neurofibromatosis, colon cancer, breast cancer and melanoma. It also has an active experimental therapeutics research thrust and is building capacity for early phase clinical trials.
    - The University of Utah Molecular Medicine Program is an interdisciplinary effort to support and train physician researchers, who are critical to advancing novel treatments for a variety of human diseases and conditions, including cardiovascular and diabetes/metabolism. It is closely aligned with the clinical departments at the University of Utah, the Department of Human Genetics and the Utah CTSA. It also organizes the core faculty to support the MD-PhD program, Summer Medical Research Program, Howard Hughes Medical Institute med-to-grad PhD track and other NIH funded training programs.
- Brigham Young University also has active biopharmaceutical-related research efforts underway including:
    - The BYU Cancer Research Center involving 17 faculty from across the Colleges of Physical and Mathematical Sciences, Life Sciences, Health and Human Performance, and Engineering and Technology, working on cancer-related drug and diagnostic discovery, cancer biochemistry, cancer genetics, cancer immunology and cancer epidemiology and

bioinformatics. Among its most active programs are screening for anti-cancer molecules, use of DNA microwires for cancer detection and genetic processes involved in cell division.

- Other biomedical research underway at BYU includes: Research into genetic risk factors for Alzheimer's disease; Research into targeting AMP-activated protein kinase for prevention and treatment of type 2 diabetes; and Research into HIV treatment to address reservoirs or sites where HIV escapes intervention by drugs or the immune system.

Natural Products and Dietary Supplements

According to the Dietary Supplement Health and Education Act of 1994, a dietary or nutritional supplement is any product that contains one or more dietary ingredients such as a vitamin, mineral, herb or other botanical, amino acid, or other ingredient used to supplement the diet. Dietary supplements come in a variety of forms: traditional tablets, capsules, and powders, as well as drinks and energy bars. Popular supplements include vitamins D and E; minerals like calcium and iron; herbs such as echinacea and garlic; and specialty products like glucosamine, probiotics, and fish oils. Dietary supplements are not food additives (such as saccharin) or drugs. It is estimated by the NIH Office of Dietary Supplements that Americans spend about $25 billion a year on dietary supplements and at least 50,000 products are available that contain dietary supplements.

There is an active effort at the National Institutes of Health to investigate the potential roles of dietary supplements in promoting health and reducing the risk of chronic disease. Much of this work is done in concert with other NIH institutes and centers. In 2010, 89 NIH-supported projects focused on the health impacts of dietary supplements for conditions such as age-related disease, anti-cancer activity, bone health, inflammatory disease prevention, asthma, cardiovascular disease, heart failure, sickle cell disease, malaria, maternal and child health, obesity, and diabetes, among other health conditions.

HOW IT BUILDS ON UTAH STRENGTHS

- A detailed listing compiled by the Utah Technology Council identified over 100 natural products and dietary supplement companies in Utah. It is estimated that these Utah natural products and dietary supplement companies account for up to 20 percent to 30 percent of the entire U.S. market.
- While there is not one single industry classification for these natural products and dietary supplement companies, the strength of this area for Utah is revealed in examined more standard industry databases:
    - 17 of Utah's natural products and dietary supplement companies fall into the Pharmaceutical Preparation Manufacturing industry, which is 105 percent more specialized than the nation, grew a robust 25.6 percent from 2001 to 2010, and reached 3,892 jobs in 2010.
    - Another 11 of the natural products and dietary supplement companies fall within the Medicinal and Botanical Manufacturing industry, which is 3.3 times more specialized in Utah than the nation and grew by 7.8 percent from 2001 to 2010, reaching 760 jobs in 2010.

- Utah comprises 4.6 percent of all vitamin companies found in the CorpTech database of technology companies.

- The nutrition supplement and functional foods area stands out as a distinct Innovation Theme based on the cluster analysis of patents and publications activities. The types of activities include research on the use of supplements to treat diseases, chemical analysis of nutritional content, probiotics, and impacts of fiber intake on weight reduction, and improved content of cheese production.
    - In scholarly activity, Utah stands out in nutrition and dietetics with 117 publications from 2005 to 2009, which represents 1.2 percent of all U.S. publications. Particularly impressive is that Utah is 174 percent higher in the level of citations per publication, a measure of quality of publications, than the national average.
    - A key new university resource in the area of nutritional supplements and functional foods is Utah State University's Applied Nutrition Research program, supported by USTAR. The Center is located in a newly constructed 110,000 sq ft building at the USU Innovation Campus with state-of-the-art metabolic kitchen and research facilities with medical staff in which clinical research can be conducted in collaboration with industry. Currently the Center works with food and natural product companies in and outside the state of Utah to help them better substantiate claims and identify new health-related properties for their products. Among the key research efforts under way at the Center includes identifying new bioactives—plant or animal compounds with health benefits that extend beyond any traditional nutritional value—that can fight obesity, type II diabetes and cardiovascular disease where the team can scale up their research, focus on gut biology and ways to control the appetite for dietary fat as well as the neurological and biological impacts of fatty food consumption and exercise on the brain as a determining factor for type II diabetes and obesity.

[1] A Location Quotient (LQ) is a metric used to gauge the relative concentration of jobs in a particular industry in the state relative to the nation. When the LQ is 1.2 or greater, the region is said to have a "specialization" in the industry.

[2] Revenues consist of the revenues of the life science cluster, estimated by IMPLAN based on employment, plus life science-related R&D expenditures by state academic institutions.

[3] Taking the Pulse of Bioscience Education in America: A State-by-State Analysis, A Report Prepared by Battelle in Cooperation with Biotechnology Industry Organization and the Biotechnology Institute, May 2009.

[4] School Testing Results: How Utah Compares to States With Similar Demographics. Utah Foundation, Report Number 697, September 2010.

[5] Technology, Talent and Capital: State Bioscience Initiatives 2008, www.bio.org/local.

[6] These detailed industries are the six-digit level industries found in the North American Industry Classification System (NAICS).

Utah System of Higher Education
60 South 400 West
Salt Lake City, UT 84101-1284

higheredutah.org

Battelle
505 King Avenue
Columbus, OH 43201

battelle.org

Governor's Office of Economic Dev.
State of Utah
324 South State Street, Suite 500
Salt Lake City, UT 84111

business.utah.gov

Department of Workforce Services
State of Utah
140 East 300 South
Salt Lake City, UT 84111

jobs.utah.gov