



# Colorado Bioscience Roadmap 2008

Prepared for:

Colorado BioScience Association

Prepared by:

Battelle's Technology Partnership Practice

November 2008

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Prepared by: Battelle Technology Partnership Practice

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Colorado BioScience Association

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### **Colorado Biosciences: Facts and Figures\***

- Colorado's bioscience sector employed 18,000 in 2006, spanning 920 establishments
- Bioscience employment grew 5.5 percent between 2001 and 2006, outpacing total private sector job growth
- The number of research, testing, and medical laboratory establishments increased 58 percent between 2001 and 2006
- The average bioscience annual wage of \$67,320 is 54 percent more than the private sector annual average wage in Colorado
- The Denver Metro region ranks 19th among all U.S. metro areas in the size of its medical device sector
- Boulder ranks first in the nation in its concentration of employment in the medical device sector among medium-sized metros and is one of only 14 metro areas that has a specialization in three of the four bioscience subsectors
- Since 2001, the Greater Fort Collins metro area has added 37 percent to its bioscience employment base
- Academic medical research and development grew more than 72 percent from 2002 to 2006, almost twice the national growth rate of 37 percent
- Thirty-eight bioscience companies were formed based on University of Colorado-developed technologies between 2002 and 2007, with CU now producing about 10 new bioscience companies annually
- Thirteen new bioscience companies were spun out of Colorado State University between 2002 and 2007
- A total of \$1.3 billion was invested in Colorado bioscience companies between 2002 and the second quarter of 2008
- Colorado ranks 11th among the 50 states in bioscience venture capital investments for the 2002–2007 time period

\* For all data in the report, the most recent data available were used. For some data sets, such as employment data, 2006 is the most recent year for which data are available; other data are available for 2007 or 2008. For this reason, differing time periods are used.



# EXECUTIVE SUMMARY

## Introduction

In 2003, Colorado committed to making the biosciences a key driver of the state's future economy. The public and private sectors cooperated in developing **Colorado's Place in the Sun: An Action Plan to Grow Colorado's Bioscience Cluster**. The Plan proposed a series of strategies and actions designed to distinguish Colorado as a preeminent life science health care center and home to a vibrant cluster of bioscience companies.

Five years later, Colorado has progressed significantly in positioning the biosciences as a key driver of the state's economy. But, while Colorado has been investing in its bioscience sector and the infrastructure to support it, the national and global bioscience landscape has evolved, and states and regions across the United States are advancing bold initiatives to capture both the economic and social benefits of new bioscience discoveries – discoveries that are increasingly finding their way into new applications and products leading to new medical treatments, new sources of energy, and new industrial products made out of biomaterials.

Together, these changes call for a fresh assessment of Colorado's position and current opportunities for bioscience-driven economic development. The Colorado BioScience Association (CBSA), with support from the Governor's Office of Economic Development and International Trade (OEDIT) and Colorado's research institutions, industry partners, and economic development organizations, initiated the development of this Roadmap to assess progress that has been made in implementing the 2003 Action Plan, evaluate Colorado's competitive position in the biosciences, and identify strategies and actions to be undertaken during the next 5 years to position the bioscience sector as a key driver of Colorado's economy. CBSA engaged Battelle's Technology Partnership Practice to assist in developing this Roadmap.

## Project Methodology

This Roadmap was developed with guidance and input from the state's research institutions, bioscience companies, and other public and private leaders. The 2003 Action Plan identified crucial bioscience areas in which Colorado's research institutions had demonstrated strengths and proposed technology platform areas that appeared to offer the greatest opportunity for future growth, given the state's research and development (R&D) capabilities and market trends at the time. The first step in developing this Roadmap was to update the core competency analysis in order to confirm that areas of expertise identified in 2003 continue to be areas of competitive advantage for Colorado, to identify new emerging areas of expertise, and assess opportunity areas in light of today's marketplace (Figure ES-1). In addition to examining Colorado's research base, the Battelle team assessed the performance of Colorado's bioscience industry sector by examining bioscience employment and establishment data for the 2001 to 2006 time period.

To assess progress on achieving the actions proposed in 2003 and to identify those areas that still need to be addressed, Battelle interviewed academic, research, business, and civic leaders and held focus groups to validate the findings from the interviews. Focus group participants also provided input on potential strategies and actions for addressing gaps that may be hindering the development of Colorado's bioscience sector.

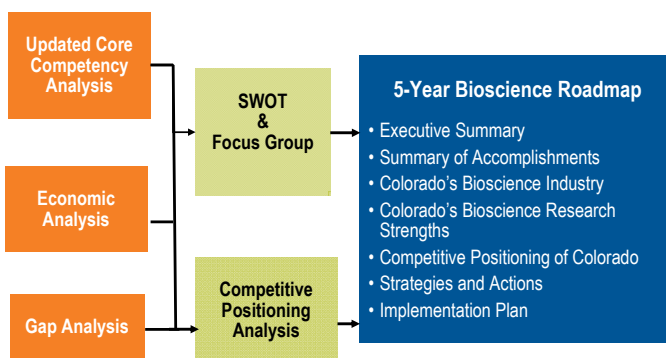
### Colorado Bioscience Roadmap Steering Committee

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Jerry McCarthy, WIRED  
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Robin Shandas, CU  
Christine Shapard, CBSA  
John Tayer, Roche

**Figure ES-1: Overview of Project Methodology**

This Roadmap, which summarizes the key findings of these analyses, includes the following:

- A discussion of key accomplishments since 2003
- An analysis of Colorado’s bioscience industry and R&D base
- Identification of crucial areas that need to be addressed to accelerate the growth of Colorado’s bioscience sector
- A renewed statement of Colorado’s vision for its bioscience future
- A proposed set of strategies and actions that, if enacted, will help achieve this vision
- An implementation plan that identifies immediate priorities and performance metrics.



## Key Findings

### Accomplishments

**Colorado has a growing base of successful bioscience companies.** Colorado’s bioscience industry sector is coming of age as both the number of bioscience companies succeeding in getting products to the market and the number of new companies being created increased significantly during the past 5 years, as did the number of companies that attracted high-value investment from leading bioscience companies. In some cases, firms initially headquartered out of state have spun off new Colorado-based bioscience companies.

**The CBSA, which was created as a direct result of the 2003 Action Plan, has emerged as a strong advocate for the biosciences and contributed to the development of a much stronger bioscience community.** The 2003

Action Plan called for the development of a single, unified Colorado BioScience Association that would serve as a clearinghouse for information on the biosciences in Colorado, advocate on behalf of the biosciences, identify needs and develop proposals for policies and programs to address those needs, act as a matchmaker and networker, and promote the image of Colorado as a center of the biosciences. CBSA has succeeded in addressing each of these functions. Bioscience leaders interviewed for this Roadmap consistently cited CBSA and the role it has played in strengthening the state’s bioscience cluster as a key accomplishment during the past 5 years.

#### Colorado Bioscience Firms Attract High-Value Investments

Myogen, Inc. was acquired by Gilead for \$2.6 billion in 2006.

Pharmion was sold for \$2.9 billion to Celgene

Boulder-based Sirna Therapeutics was acquired by San Francisco-based pharmaceutical giant Merck & Co. in 2006 for \$1.1 billion

Tyco Healthcare Group was spun off as Covidien in 2007, with a \$20 billion market capitalization

**State government recognition and support of the biosciences have increased significantly since 2003.**

Colorado policymakers and legislators have greater understanding of the bioscience sector, its importance to the future of Colorado's technology-driven economy, and the opportunities it presents to benefit Colorado residents by offering high-wage jobs and improved quality of life. The Governor's economic development program targets the biosciences as a critical emerging industry sector. In addition to the legislation that created the Bioscience Discovery Evaluation Grant Program (House Bill [HB] 06-1360) in 2006, legislation was enacted in 2007 allocating another \$2.5 million targeted to Small Business Innovation Research/Small Business Technology Transfer Program (SBIR/STTR) recipients and biofuels/bioscience (HB 07-1060). In April 2008, the Governor signed a 5-year, \$26.5 million package that creates a Bioscience and Life Science Fund (HB 08-1001). Legislation was passed in 2007 creating the Renewable Energy Collaboratory, a partnership of University of Colorado at Boulder (CU-Boulder), the Colorado School of Mines, Colorado State University (CSU), and the National Renewable Energy Laboratory. The Collaboratory, which will receive \$2 million annually in state funding for 3 years beginning in 2007, will conduct world-class research to develop new energy technologies and transfer them to the private sector.

**Colorado Bioscience Legislation**

Bioscience Discovery Evaluation Grant Program (HB 06-1360) created to fund proof-of-concept activities, 2006

Allocation of additional \$2.5 million in 2007 (HB 07-1060)

Creation of Bioscience and Life Science Fund (HB 08-1001), \$26.5 million over 5 years to support commercialization of bioscience discoveries

**Colorado has made progress in addressing the early-stage capital needs of emerging bioscience companies.** In addition to the state funding provided to support proof-of-concept (PoC) activities, Colorado's universities are also providing PoC funding and efforts are ongoing to increase the supply of early-stage risk capital in the state. In 2005, the CU Technology Transfer Office began a competitive funding program called the Proof of Concept Grant Program (POCg). POCg provides awards to enable the development and validation of promising CU inventions that are, or will become, suitable for commercialization. CU also makes Proof of Concept investments (POCi), which are early-stage seed investments in the form of convertible debt to enable further development of technologies that are the platform for a start-up company. CSU launched three Superclusters – Infectious Disease, Cancer, and Clean Energy – each of which provides funding of product development grants.

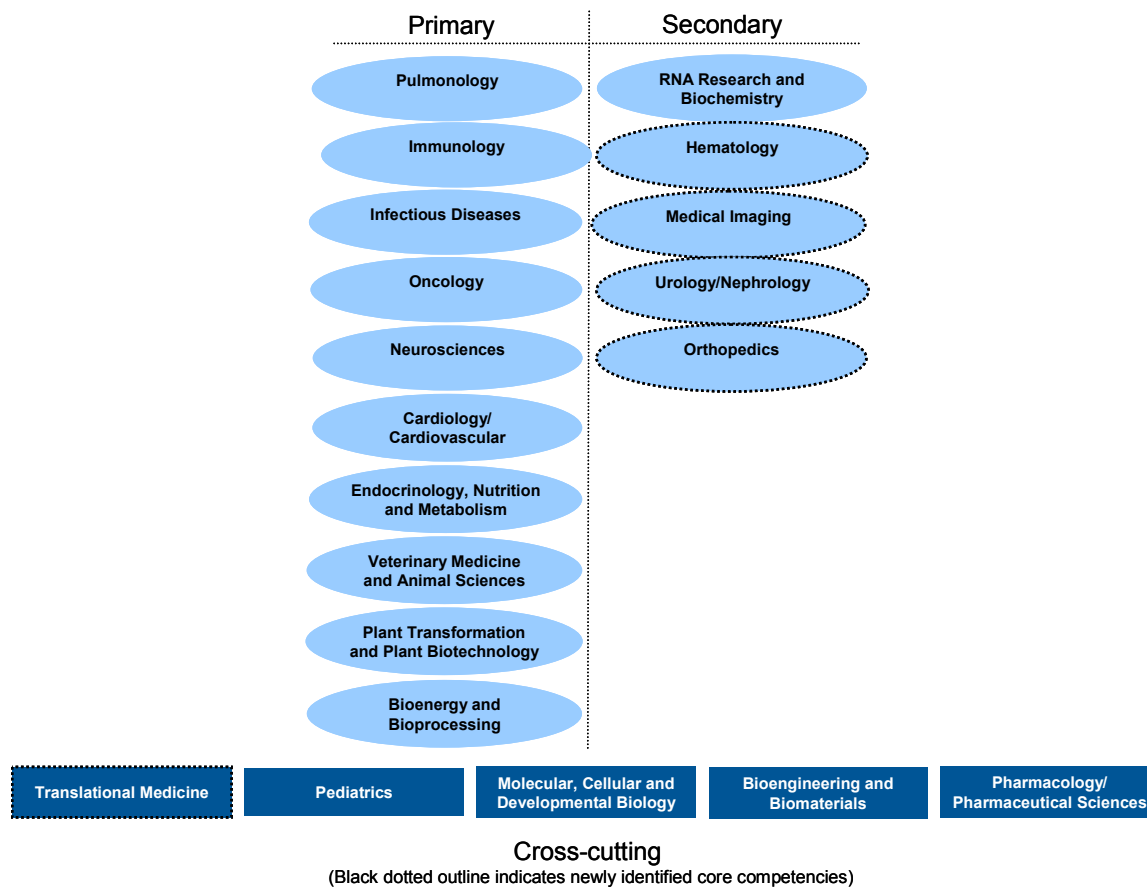
**Colorado has also made progress in building an entrepreneurial support infrastructure for start-up bioscience companies.** Colorado has a growing number of organizations that provide business planning and management advice to entrepreneurial endeavors, some of which are targeted to the biosciences while others serve bioscience and other technology companies. These include Fitzsimons BioBusiness partners (FBBp), Boulder Innovation Center (BIC), Rocky Mountain Innovation Initiative (RMI<sup>2</sup>), and Longmont Entrepreneurial Network (LEN).

**Colorado's universities have demonstrated a strong commitment to achieving bioscience research excellence in crucial bioscience research areas and to facilitating the commercialization of discoveries.** The 2003 Action Plan called for expanding Colorado's research base and building research excellence in the state's bioscience niches. The data show that Colorado's bioscience-related R&D expenditures grew 38.6 percent between 2002 and 2006, from \$292 million to \$405 million. This rate of growth was greater than the 36.9 percent national rate over the same time period. Of note, medical sciences R&D in Colorado grew tremendously by 72.4 percent from 2002 to 2006, compared with 37.4 percent growth nationally.

Both CSU and CU have made significant investments in their respective technology transfer and commercialization functions and expanded greatly their focus on facilitating the process of moving research discoveries into commercial products and applications. Bioscience company executives and other members of Colorado's life science community interviewed for this Roadmap noted these changes as an area in which the greatest progress has been made since the 2003 Action Plan was adopted.

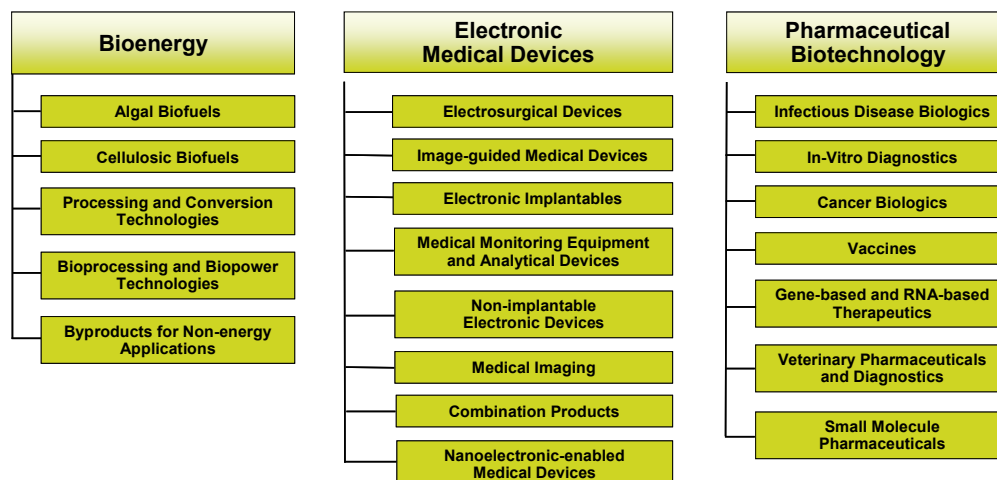
**Colorado's universities and research campuses have added additional bioscience core competencies.** Research core competencies are those fields with a critical mass of ongoing activity with demonstrated excellence. Using both quantitative and qualitative methods, Battelle identified 20 areas of core competence within the biosciences in Colorado, as shown in Figure ES-2.

Figure ES-2: Colorado's 2008 Research Core Competencies\*



Colorado’s research core competencies suggest three strategic areas or “technology platforms” that, if nurtured, are likely to led to significant industry growth. These are Bioenergy, Electronic Medical Devices, and Pharmaceutical Biotechnology. Figure ES-3 lists key applications within each of the platform areas.

Figure ES-3: Colorado's 2008 Bioscience-Related Technology Platforms and Key Applications

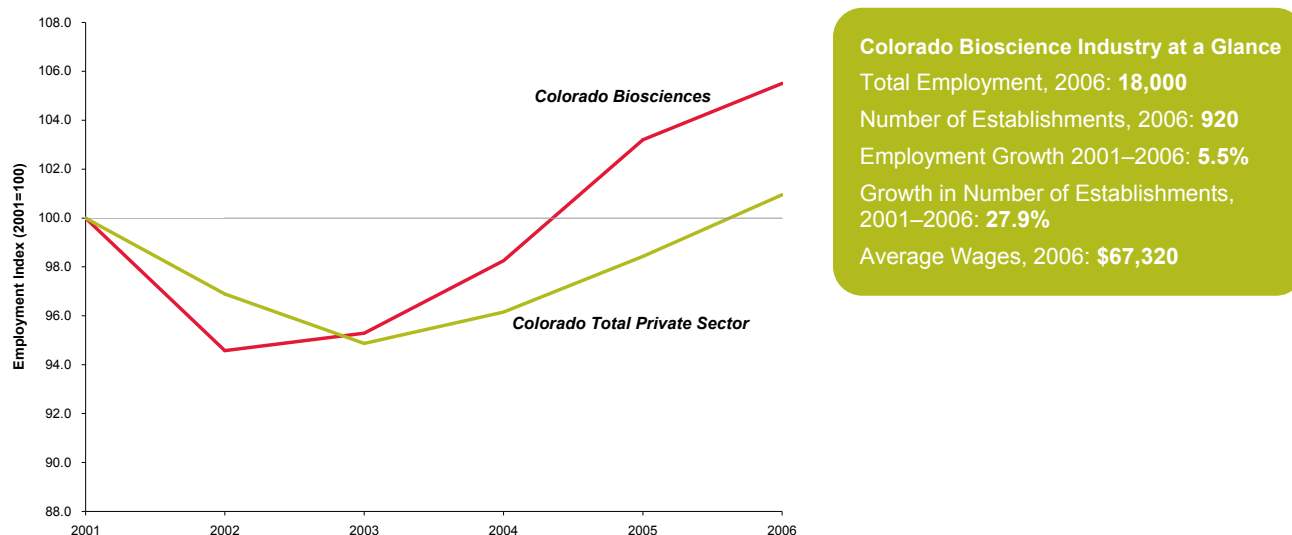


Clearly, Colorado has accomplished many of the actions proposed in the 2003 Action Plan and is well positioned to continue to grow its bioscience economy. The state and its metro areas continue to see bioscience industry growth.

## Colorado's Bioscience Industry

**Colorado has added to its bioscience industry base.** The bioscience sector employed nearly 18,000 in 2006 and spanned 920 individual business establishments.<sup>1</sup> The number of bioscience establishments increased by 28 percent between 2001 and 2006, growing much more rapidly than the national rate of 16 percent, suggesting that employment will continue to increase as these establishments grow. Colorado's employment base results in a bioscience location quotient (LQ) of 0.83 or a statewide job concentration that is 83 percent of the national average.<sup>2</sup> Colorado, while not considered to have a specialization in its overall bioscience sector, has distinct niches among the primary bioscience subsectors and strong clusters or pockets of activities among several of its major metropolitan areas. Colorado's bioscience sector grew by 5.5 percent during the 2001 to 2006 period, outpacing the national private sector that grew by 3.1 percent. Bioscience jobs are increasing much more quickly than jobs in the total private sector, as shown in Figure ES-4.

**Figure ES-4: Employment Growth in Colorado Biosciences and Total Private Sector, 2001–2006**



Source: Battelle calculations of data from the Minnesota IMPLAN Group.

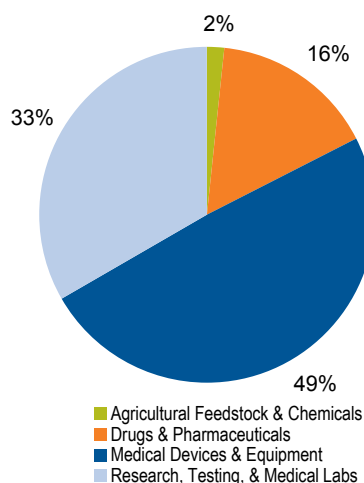
**Colorado has a diversified bioscience base with industry strengths in medical devices and equipment and research, testing, and medical laboratories.** In Colorado, core bioscience activities center around the state's large and specialized medical device and equipment subsector and its sizable and rapidly growing research, testing, and medical laboratories subsector. Medical device firms in Colorado employ approximately one-half of state bioscience workers (Figure ES-5). Research, testing, and medical laboratories employed one-third of all bioscience workers, a share that has risen from 28 percent since 2001. Colorado's emerging research, testing, and medical laboratories subsector has outpaced job growth in the national sector,

<sup>1</sup> The term "establishment" used throughout this analysis is not synonymous with a "company." A firm or employer can have one or more establishments. An establishment is an economic unit, such as a farm, mine, factory, or store that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. CBSA estimates that the state's 920 bioscience establishments translate into approximately 460 bioscience companies.

<sup>2</sup> Location quotients are a common measure of the concentration of a particular industry in a state or region relative to the nation (reference area). The LQ consists of the ratio of the share of total regional employment that is in the particular industry and the share of total employment in the nation (reference area) that is in the particular industry. An LQ greater than 1.0 for a particular industry indicates that the region is relatively concentrated, whereas an LQ less than 1.0 signifies a relative under-representation. An LQ above 1.20 denotes employment concentration well above the national average. The minimum concentration threshold for declaring a regional specialization is a matter of judgment and varies somewhat in the relevant literature. In this analysis, regional specializations are defined by LQs of 1.2 or greater.

adding more than 25 percent to its employment base since 2001. Firms that manufacture drugs and pharmaceuticals also have a presence in the state, accounting for 16 percent of total sector jobs.

**Figure ES-5: Colorado Bioscience Employment by Subsector, 2006**



**Denver-Aurora** ranks 19th among all U.S. metro areas in the size of its medical device subsector.

**Boulder** is one of only 14 metro areas in the United States to have a specialization in three of the four bioscience subsectors and ranks first in the nation in its concentration of employment in the medical device subsector among medium-sized metro areas.

**Fort Collins** has a specialization in medical devices and research, testing, and medical labs.

**Colorado Springs** has a concentration in medical devices and equipment, but experienced some bioscience job loss between 2001 and 2006.

Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

**Colorado’s bioscience sector provides high-wage jobs.** In 2006, Colorado bioscience workers earned, on average, just over \$67,000 per year. This compares with \$43,664 for the average overall private sector wage (Table ES-1). The premium paid to these workers – at nearly \$24,000 (or 54 percent more) – is similar to the national premium (nearly \$29,000 or 61 percent more). In fact, each major bioscience subsector pays, on average, more than the average private sector wage.

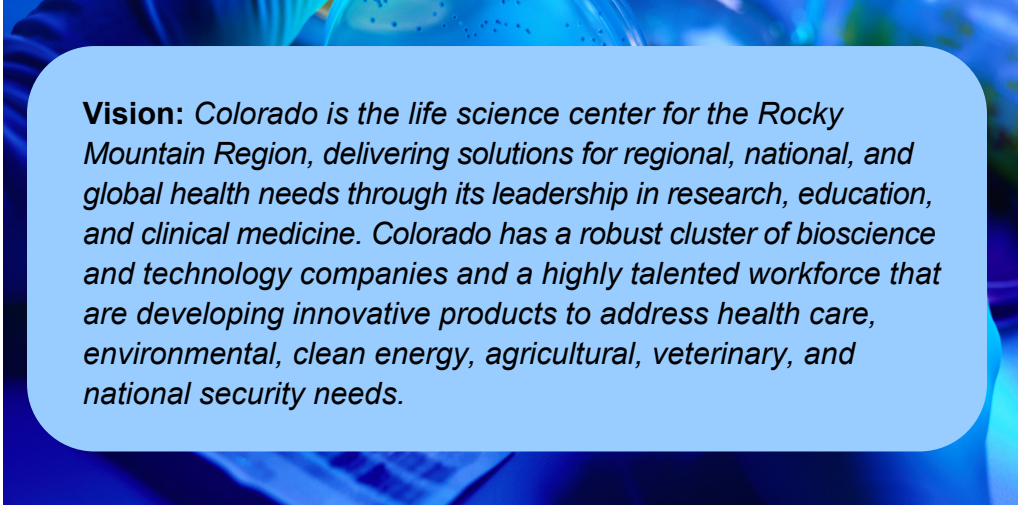
**Table ES-1: Average Annual Wages for Colorado Biosciences and Other Major Industries, 2006**

Major Industries & Bioscience Subsectors	Avg. Annual Wages, 2006
Management of Companies and Enterprises	\$ 101,806
Information	\$ 76,257
<b>Research, Testing, &amp; Medical Laboratories</b>	<b>\$ 74,722</b>
<b>Drugs &amp; Pharmaceuticals</b>	<b>\$ 74,707</b>
Professional, Scientific, and Technical Services	\$ 71,544
<b>Total Biosciences</b>	<b>\$ 67,320</b>
Finance and Insurance	\$ 65,095
<b>Medical Devices &amp; Equipment</b>	<b>\$ 60,615</b>
Manufacturing	\$ 54,865
<b>Agricultural Feedstock &amp; Chemicals</b>	<b>\$ 47,980</b>
<b>Total Private Sector</b>	<b>\$ 43,664</b>
Construction	\$ 43,215
Real Estate and Rental and Leasing	\$ 41,071
Health Care and Social Assistance	\$ 40,205
Arts, Entertainment, and Recreation	\$ 29,592
Retail Trade	\$ 25,849

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Colorado’s growing bioscience industry base coupled with the state’s bioscience research capabilities suggest that Colorado can realize its desire to make the biosciences a key driver of the state’s future economy.

## Colorado's Bioscience Future



**Vision:** *Colorado is the life science center for the Rocky Mountain Region, delivering solutions for regional, national, and global health needs through its leadership in research, education, and clinical medicine. Colorado has a robust cluster of bioscience and technology companies and a highly talented workforce that are developing innovative products to address health care, environmental, clean energy, agricultural, veterinary, and national security needs.*

Colorado has developed the above vision for its bioscience future. Achieving this vision will require significant future investment if Colorado is to become a leading center of the biosciences. Moving forward, Colorado will need to

- Continue to implement actions to increase the availability of capital at each stage of investment cycle for bioscience companies;
- Develop a seamless bioscience technology commercialization network that provides support to bioscience entrepreneurs, start-ups, and emerging bioscience companies;
- Ensure that Colorado is developing, attracting, and retaining a population with the skills and education needed to support the bioscience sector;
- Invest in the state's bioscience research infrastructure to keep Colorado and its researchers at the cutting edge of bioscience research and the application of discoveries in the marketplace; and
- Strategically focus on technology areas, or platforms, that offer the greatest potential for differentiating Colorado and growing a globally competitive bioscience industry, including bioenergy, electronic medical devices, and pharmaceutical biotechnology.

## Strategies and Actions

Five strategies and 16 actions are proposed to address these strategic issues.

### ***Strategy 1: Ensure availability of capital for bioscience companies at all stages of their development.***

One characteristic shared by leading bioscience states and regions is that they are home to a robust capital community that is both oriented toward early-stage investment and committed to local investment. It is critical to have local pre-seed, seed, and venture capital funds with experience investing in bioscience companies. Fortunately for Colorado, several local venture funds have supported the development of many of the state's successful bioscience companies. But, the funds based or with a presence in Colorado are small and can invest in a limited number of deals.

As Colorado's industry matures, its risk capital market must be able to address the continuum of capital needs from prototype through seed to later-stage formal venture financing. Five actions are proposed to ensure that Colorado bioscience companies will have access to capital at each stage of development. These actions include using tax policy to encourage investment by angel investors, exploring options to create a refundable or transferable R&D tax credit for bioscience companies, continuing to fund commercialization and PoC, marketing Colorado bioscience opportunities to out-of-state investors and venture funds, and making investments in private venture funds.

### ***Strategy 2: Create a robust technology commercialization infrastructure in Colorado to rapidly move discoveries into the marketplace.***

Despite the fast pace of bioscience research discoveries, a national crisis exists in the ability to translate innovative research discoveries into biomedical products. By itself, research will not translate into commercialization. This gap between research discoveries and developing innovative new products is a well-recognized "valley of death" that suggests the need for a continuum of support, services, and assistance from the private and public sectors as a technology enterprise is conceived, developed, formed, and grown and reaches maturity. Tools needed to overcome the "valley of death" include conducting due diligence to determine the market potential, undertaking PoC applied research to demonstrate commercial viability, and supporting engineering optimization in developing the technology into prototypes that meet the demands of the marketplace. For the biosciences, the "valley of death" is a much longer and expensive process than for other technology areas due to the highly regulated nature of bioscience innovation.

Colorado has begun to put in place tools to advance technology commercialization by providing support for PoC activities. As more technologies advance through this stage, they will be better positioned to attract seed, early-stage, and later-stage venture capital. Colorado can help ensure that companies are able to obtain such capital by helping them develop effective business plans, access executive and management expertise, and access an infrastructure that supports preclinical development.

### ***Strategy 3: Ensure that Colorado is attracting, retaining, and producing individuals with the skills needed to meet future bioscience workforce needs.***

The demands for a highly trained, technical workforce in today's knowledge-based economy are extraordinary and mounting. This is particularly true in the biosciences. At its core, the bioscience industry is a knowledge-based sector dependent upon the skills of its workers. Workers are needed to conduct research, translate innovation into product development and improved health care techniques, and ultimately to manufacture biomedical and other bioscience-related products. Thus, ensuring the availability of an educated, skilled workforce is critical to developing and sustaining a highly competitive, robust bioscience cluster over the long term. Colorado must continue to advance a pipeline of bioscience talent to support the future

#### **What is Technology Commercialization?**

Technology commercialization brings together the technology derived from the research interest, risk capital to develop and engineer the product for manufacture and distribution, and entrepreneurial management talent to manage and steer the firm or product into and through the marketplace.



growth of this sector by preparing high school science teachers to teach the biosciences, encouraging bioscience students and workers to obtain business and entrepreneurial skills, and providing opportunities for bioscience graduates to gain industry experience.

#### ***Strategy 4: Promote Colorado’s position as a leading bioscience center.***

Colorado has an emerging bioscience cluster and very strong bioscience research assets, but neither Colorado nor its metro areas are generally recognized as leading bioscience centers. Progress has been made within the state in raising the visibility of the bioscience sector as a key driver of the state’s technology economy in the last 5 years, and the state’s business development efforts include a focus on the bioscience industry. During the next 5 years, Colorado will need to promote its bioscience assets both nationally and globally. It will be important to differentiate Colorado from the various states and regions across the United States that also are seeking to grow their bioscience economies. Colorado can do this by developing and implementing a branding and marketing strategy that focuses on the state’s bioscience technology platforms and continuing to implement a bioscience business development effort.

#### ***Strategy 5: Establish Colorado’s bioscience future by making a long-term commitment to bioscience industry development.***

To be a global leader in the biosciences, the State of Colorado must demonstrate its commitment to the biosciences by recognizing the sector’s contribution to the state’s economy and fully supporting the significant investments that will be required over the long term in the state’s bioscience research and commercialization infrastructure. Taking note of the investments of competitor states aids understanding of the magnitude of the investments being made in the biosciences. Massachusetts enacted a 10-year, \$1 billion Life Sciences Initiative in 2008. This umbrella program includes \$500 million in capital funding, \$250 million in granting authority, and \$250 million in tax credits. The initiative will provide funding for major university R&D facilities and make miscellaneous improvements in biomanufacturing and wet-lab incubation. The Governor of Maryland has proposed a similar 10-year, \$1.1 billion bioscience initiative that will be considered by the Legislature in 2009. If Colorado wishes to compete in the biosciences, it must continue to invest in its bioscience research, commercialization, and health care infrastructure at the same time continuing to address the needs of its bioscience companies.

#### **States are investing significant resources to develop their bioscience infrastructures**

- Massachusetts Life Sciences Initiative – \$1 billion
- Missouri Lewis and Clark Discovery Fund – \$335 million
- Texas Emerging Technology Fund – \$100 million annually
- Washington State Life Sciences Discovery Fund – \$350 million

Table ES-2 lists the individual strategies and actions. It includes an estimate of the resources that would be required for each action, the level of importance, and the proposed time frame for implementation. Immediate actions should be undertaken in the next 12 months. Short-term actions should be undertaken in 1 to 3 years, and mid-term actions should be undertaken in 3 to 5 years.

**Table ES-2: Proposed Strategies and Actions**

Action	Priority	Time Frame	Estimated Cost
<b>Ensure availability of capital for bioscience companies at all stages of their development</b>			
Use tax credits to encourage private investment in early-stage capital and bioscience companies	High	Short-term	Initial cap of \$5 million for each tax credit
Explore options for creating a refundable or transferable R&D tax credit for bioscience firms	Medium	Short-term	Existing resources
Expand the existing biotechnology sales and use tax credit to medical device companies	Critical/High	Short-term	\$2 million to \$2.5 million annually
Continue and increase funding for the Bioscience and Life Science Fund (HB 08-1001) and allocate the additional funds for investments in bioscience companies	Critical	Mid-term	\$7 million annually
Undertake activities to make out-of-state venture capital funds aware of opportunities in the Rocky Mountain region	High	Immediate	Existing resources
Explore options to create a \$250 million Fund of Funds with an emphasis on seed and early-stage funds	High	Short-term	\$250 million
<b>Create a robust technology commercialization infrastructure in Colorado to rapidly move bioscience discoveries into the marketplace</b>			
Add bioscience capacity to local business development and entrepreneurial support networks	Critical	Short-term	\$300,000 to \$400,000 annually
Establish a Bioscience Executive Corps to serve as mentors to start-up bioscience companies	High	Short-term	Included in funding to add bioscience capacity to existing business development organizations
Create a Colorado Drug, Diagnostic, and Device Development Institute	High	Short-term	\$300,000 study underway to develop business plan Annual cost estimated at \$4 million to \$5 million
<b>Ensure that Colorado is attracting, retaining, and producing individuals with the skills needed to meet future bioscience workforce needs</b>			
Create and fund a high school science teacher externship program	High	Immediate	\$600,000 annually
Establish a Bioscience Industry Fellows Program to place graduate and postdoctoral students in emerging bioscience companies	High	Short-term	\$375,000 (five fellows at \$75,000 annually)
Continue to expand efforts to provide business and entrepreneurial education to bioscience students and to increase educational offerings that address critical skill needs	Medium	Mid-term	TBD
Create a nonprofit CBSA Foundation to develop and support bioscience programs to ensure that Colorado has the talent to meet the future workforce needs of the state's bioscience sector	Critical	Short-term	Initial planning can be conducted with existing CBSA resources. Programmatic funding needs TBD
<b>Promote Colorado's position as a leading bioscience center</b>			
Ensure that the Governor's Office of Economic Development and International Trade continues to maintain dedicated bioscience staff	Critical	Immediate	Existing resources
Develop and implement a bioscience branding and marketing strategy and communications campaign	High	Short-term	\$500,000 Funds provided by various economic development partners
<b>Establish Colorado's bioscience future by making a long-term commitment to bioscience industry development</b>			
Continue to support ongoing bioscience development projects and fund new ones as needed, including Anschutz Medical Campus, Colorado Science + Technology Park, CIMB, CSU Superclusters, and Renewable Energy Collaboratory	Critical	Ongoing	Determined on project-by-project basis
Identify revenue sources and create a fund to support bioscience policies, programs, and infrastructure investments in the long term	Critical	Short-term	TBD

## Implementation Plan

It is proposed that the following ten actions be undertaken in the first year of strategy implementation.

- Hold a Governor's Capital Summit to begin planning for a Fund of Funds.
- Implement a statewide business development and entrepreneurial support network through CBSA.
- Identify experienced bioscience executives willing to mentor bioscience entrepreneurs and emerging bioscience firms.
- Create CBSA Foundation to focus on talent issues.
- Propose legislation creating tax credits for angel investors and investors in early-stage venture funds.
- Propose legislation to expand the biotechnology sales and use tax credit to medical device companies.
- Propose legislation to create and fund a science teacher externship model program.
- Initiate Rocky Mountain Investor Conference in 2009.
- Begin discussions and initial planning for the Colorado Bioscience Fund.
- Develop a business plan for the Colorado Drug, Diagnostic, and Device Development Institute.

## Conclusion

In 2003, the Action Plan team found that Colorado had a substantial foundation on which to build a bioscience industry cluster. In 2008, the Battelle team finds that significant progress has been made on many fronts in terms of building that cluster. Colorado is home to both established and emerging bioscience companies, with a very strong and specialized medical device subsector and a rapidly growing research, testing, and medical laboratories subsector. Colorado's metropolitan areas are home to strong clusters of bioscience activity, each with its own distinct niche. Colorado has continued to build its research strengths and has the potential for becoming truly world-class, working across institutions to advance its bioenergy, electronic medical devices, and pharmaceutical biotechnology platforms.

But, gaps in Colorado's bioscience support infrastructure still need to be addressed if Colorado's bioscience sector is to become a national and global leader. Colorado could become a leader in translational medicine; but, to do so will require significant investments on the part of public and private sectors and a commitment to continue to develop a climate supportive of the biosciences. Colorado must ensure that companies are able to obtain risk capital; develop a seamless bioscience technology commercialization network; attract, retain, and develop bioscience talent; and invest in the state's bioscience research infrastructure in order to make the biosciences a driver of Colorado's future economy.

This Roadmap proposes a set of strategies and actions to address these issues and achieve Colorado's bioscience vision. It will be a challenge for Colorado to achieve the goals set out in this Roadmap; but, doing so will result in not only high-wage, high-skilled jobs but also better health care, improved environmental quality, and a better quality of life for Coloradoans.

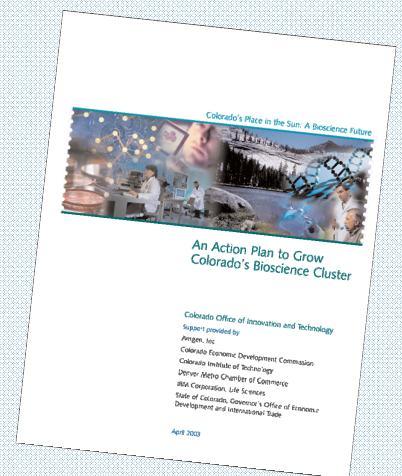


# INTRODUCTION

## Background

*In 2003, Colorado committed to making the biosciences a key driver of the state's future economy. The public and private sectors cooperated in developing **Colorado's Place in the Sun: An Action Plan to Grow Colorado's Bioscience Cluster**. The Plan proposed a series of strategies and actions designed to distinguish Colorado as a preeminent life science health care center and home to a vibrant cluster of bioscience companies. The Plan noted that realizing this goal would require the following:*

- Commitment and willingness to collaborate on the part of the public, private, and academic communities
- Achievement of research excellence with national-level focus in selected areas
- Commitment on the part of Colorado's universities to a broad commercialization program to capitalize on technology transfer and entrepreneurial activities
- Continued investment in bioscience infrastructure, including the completion of the Anschutz Medical Campus and the Fitzsimons Science and Technology Park
- Commitment on the part of the State of Colorado to support the bioscience sector.



Five years later, Colorado has progressed significantly in positioning the biosciences as a key driver of the state's economy. Colorado's academic institutions have grown their bioscience research capabilities, increased their focus on and dedicated additional resources to technology transfer and commercialization, and embarked on major investment programs aimed at continuing to develop research excellence in selected areas of the biosciences. The University of Colorado Health Sciences Center and the University of Colorado Hospital have been relocated to the Anschutz Medical Campus, Children's Hospital has relocated to the medical campus in Aurora, and the Colorado Science + Technology Park at Fitzsimons continues to be developed. The State of Colorado passed legislation in 2006, 2007, and 2008 to provide support for the biosciences and the Governor has targeted the bioscience sector as one of four critical areas of focus for the state's economic development efforts.

But, while Colorado has been investing in its bioscience sector and the infrastructure to support it, the national and global bioscience landscape has evolved, and states and regions across the United States are advancing bold initiatives to capture both the economic and social benefits of new bioscience discoveries – discoveries that are increasingly finding their way into new applications and products leading to new medical treatments, new sources of energy, and new industrial products made out of biomaterials.

Together, these changes call for a fresh assessment of Colorado's position and current opportunities for bioscience-driven economic development. The Colorado BioScience Association (CBSA), with support from the Governor's Office of Economic Development and International Trade (OEDIT) and Colorado's research institutions, industry partners, and economic development organizations, initiated the development of this Roadmap to assess progress that has been made in implementing the 2003 Action Plan, evaluate Colorado's competitive position in the biosciences, and identify strategies and actions to be undertaken

during the next 5 years to position the bioscience sector as a key driver of Colorado’s economy. CBSA engaged Battelle’s Technology Partnership Practice to assist in developing this Roadmap.

## Project Methodology

This Roadmap was developed with guidance and input from the state’s research institutions, bioscience companies, and other public and private leaders. The 2003 Action Plan identified crucial bioscience areas in which Colorado’s research institutions had demonstrated strengths and proposed technology platform areas that appeared to offer the greatest opportunity for future growth, given the state’s research and development (R&D) capabilities and market trends at the time. The first step in developing this Roadmap was to update the core competency analysis in order to confirm that areas of expertise identified in 2003 continue to be areas of competitive advantage for Colorado, to identify new emerging areas of expertise, and assess opportunity areas in light of today’s marketplace (Figure 1). In addition to examining Colorado’s research base, the Battelle team assessed the performance of Colorado’s bioscience industry sector by examining bioscience employment and establishment data for the 2001 to 2006 time period.

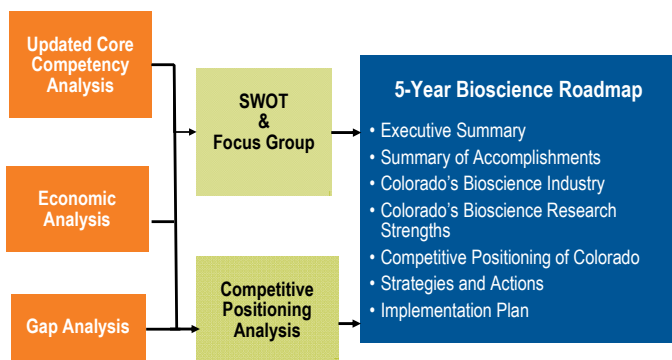
To assess progress on achieving the actions proposed in 2003 and to identify those areas that still need to be addressed, Battelle interviewed academic, research, business, and civic leaders and held focus groups to validate the findings from the interviews. Focus group participants also provided input on potential strategies and actions for addressing gaps that may be hindering the development of Colorado’s bioscience sector.

### Colorado Bioscience Roadmap Steering Committee

Jack Wheeler, MicroPhage, Chair  
 David Allen, CU  
 Holli Baumunk, Metro Denver EDC  
 Denise Brown, CBSA  
 Jeff Castleberry, EndoShape  
 Matt Cheroutes, OEDIT  
 Jill Farnham, FRA  
 Todd Gander, Covidien  
 Jerry McCarthy, WIRED  
 Terry Opgenorth, CSU  
 Robin Shandas, CU  
 Christine Shapard, CBSA  
 John Taver Roche

**Figure 1: Overview of Project Methodology**

This Roadmap, which summarizes the key findings of these analyses, includes the following:



- A discussion of key accomplishments since 2003
- An analysis of Colorado’s bioscience industry and R&D base
- Identification of crucial areas that need to be addressed to accelerate the growth of Colorado’s bioscience sector
- A renewed statement of Colorado’s vision for its bioscience future
- A proposed set of strategies and actions that, if enacted, will help achieve this vision
- An implementation plan that identifies immediate priorities and performance metrics.

# COLORADO'S RECENT KEY ACCOMPLISHMENTS

## Progress in the Biosciences Since 2003

*Colorado has a growing base of successful bioscience companies.*

Colorado's bioscience industry sector is coming of age as both the number of bioscience companies succeeding in getting products to the market and the number of new companies being created increased significantly during the past 5 years, as did the number of companies that attracted high-value investment from leading bioscience companies

As Colorado bioscience companies have demonstrated success, the level of merger and acquisition activity has increased significantly with larger, national and global companies seeking to capture the technology developed by these smaller Colorado firms. These firms have continued or expanded operations in Colorado, as evidenced by the following examples:

- **Myogen, Inc.** was acquired by Gilead for \$2.6 billion in 2006. Gilead, a biopharmaceutical company that discovers, develops, manufactures, and commercializes therapies for viral diseases, infectious diseases, and cancer, chose to locate its cardiopulmonary research and clinical development in Colorado.
- **Dharmacon RNAi Technologies** was created as a subsidiary of Thermo Fisher Scientific when Dharmacon Inc., a company that started up in Colorado in 1995, was acquired by Fisher Scientific International. Fisher Scientific International later merged with Thermo Electron to become Thermo Fisher Scientific, which remains in Colorado.
- **Pharmion**, a Colorado-based drug development company, was sold for \$2.9 billion to Celgene, a multinational pharmaceutical company.
- Boulder-based **Sirna Therapeutics** was acquired by San Francisco-based pharmaceutical giant Merck & Co. in 2006 for \$1.1 billion.

In some cases such as the following, firms initially headquartered out of state have spun off new Colorado-based bioscience companies:

- Colorado-based Valleylab became a division of Tyco Healthcare Group in 1998, and Tyco Healthcare Group subsequently relocated its Respiratory and Monitoring Solutions unit from California to Colorado. Tyco Healthcare Group was spun off as **Covidien** in 2007, with a

### Key Accomplishments Achieved Since 2003

- Growth of successful bioscience companies
- Emergence of a networked statewide bioscience community due in large part to presence of CBSA
- State government recognition and support of the biosciences
- New sources of proof-of-concept funding
- Emerging entrepreneurial support infrastructure for start-up bioscience companies
- Rapidly growing academic bioscience research base, particularly in medical sciences
- University commitment to technology transfer and commercialization
- Continued development of Anschutz Medical Campus, the Colorado Science + Technology Park at Fitzsimons, CSU's Superclusters, and the Colorado Initiative in Molecular Biology at CU-Boulder

\$20 billion market capitalization. Covidien, based in Massachusetts, is adding 1,000 employees to its Respiratory and Monitoring Solutions and Energy-based Devices units in Boulder.

- Gambro AB, a Swedish-based company, spun off Colorado-based Gambro BCT Inc., to be known as **CaridianBCT Inc.**, making it the largest medical device manufacturer headquartered in Colorado, with worldwide revenues approaching \$500 million and 2,300 employees, 1,800 of which are based in Colorado.

At the same time, Colorado continues to create new companies based on Colorado-developed technologies. From 2002 to 2007, 38 bioscience companies were formed based on University of Colorado (CU)-developed intellectual property (IP). For the past 4 years, the university has spun out an average of 10 bioscience firms annually. Colorado State University (CSU) spun out 13 new bioscience companies from 2002 to 2007. With CSU's new Superclusters initiative, spin-outs are expected to increase to 15 new companies annually by fiscal year (FY) 2011. National Jewish Health is currently working with three researchers seeking to create businesses based on their research discoveries.

*The CBSA, which was created as a direct result of the 2003 Action Plan, has emerged as a strong advocate for the biosciences and contributed to the development of a much stronger bioscience community.*

The 2003 Action Plan called for the development of a single, unified Colorado BioScience Association that would serve as a clearinghouse for information on the biosciences in Colorado, advocate on behalf of the biosciences, identify needs and develop proposals for policies and programs to address those needs, act as a matchmaker and networker, and promote the image of Colorado as a center of the biosciences. CBSA has succeeded in addressing each of these functions. The Association has achieved critical mass with approximately 400 members and an annual budget that puts the Association in the top 20 percent of state bioscience associations. CBSA sponsors more than 50 networking events, educational seminars, and informational forums focused on topics ranging from financing to clinical trials management. It organizes the annual BioWest Conference for the Rocky Mountain region, offers multiple networking opportunities, and publishes an Annual Directory of Colorado bioscience companies and resources.

CBSA has been particularly effective in working with the Governor and Legislature to promote state policies in support of the biosciences. In 2006, CBSA worked with the OEDIT to draft legislation to help develop the commercial potential of bioscience technologies under investigation within Colorado's research institutions. The resulting legislation, House Bill (HB) 06-1360, provided \$2 million in matching grants for proof-of-concept (PoC) research projects. Additional legislation proposed in 2007 and 2008, HB 07-1060 and HB 08-1001, passed, in part, due to the efforts of the CBSA (refer to description of legislation in following paragraphs).

Bioscience leaders interviewed for this Roadmap consistently cited CBSA and the role it has played in strengthening the state's bioscience cluster as a key accomplishment during the past 5 years. CBSA has also played a role in supporting the development of bioscience initiatives in Northern Colorado and in Colorado Springs. The Larimer Bioscience Initiative, which has received support from CBSA, produced and recently updated a strategic plan to guide the actions, resources, and leadership necessary to achieve the goal of growing the region into an important bioscience hub.



*State government recognition and support of the biosciences have increased significantly since 2003.*

Due in part to the efforts of CBSA, Colorado policymakers and legislators have greater understanding of the bioscience sector, its importance to the future of Colorado's technology-driven economy, and the opportunities it presents to benefit Colorado residents by offering high-wage jobs and improved quality of life. The Governor's economic development program targets the biosciences as a critical emerging industry sector. In addition to the legislation that created the Bioscience Discovery Evaluation Grant Program (HB 06-1360) in 2006, legislation was enacted in 2007 allocating another \$2.5 million targeted to Small Business Innovation Research/Small Business Technology Transfer Program (SBIR/STTR) recipients and biofuels/bioscience (HB 07-1060).

In April 2008, the Governor signed a 5-year, \$26.5 million package that creates a Bioscience and Life Science Fund (HB 08-1001). The fund will provide grants to university faculty, Colorado start-up companies, and research institutions seeking to commercialize new biotechnology drugs, biofuels, medical devices, and diagnostics. The grants can be used to support PoC projects, translational research, and incubators and to provide financing for start-up companies formed to commercialize university-developed technologies.

Colorado also has an active biofuels development program. Legislation was passed in 2007 creating the Renewable Energy Collaboratory, a partnership of CU-Boulder, the Colorado School of Mines, CSU, and the National Renewable Energy Laboratory. The Collaboratory, which will receive \$2 million annually in state funding for 3 years beginning in 2007, will conduct world-class research to develop new energy technologies and transfer them to the private sector. The state funding will be used as matching funds to enable the Collaboratory to qualify for federal and private research projects.

*Colorado has made progress in addressing the early-stage capital needs of emerging bioscience companies.*

In addition to the state funding provided to support PoC activities, Colorado's universities are also providing PoC funding and efforts are ongoing to increase the supply of early-stage risk capital in the state. In 2005, the CU Technology Transfer Office began a competitive funding program called the Proof of Concept Grant Program (POCg). POCg provides awards to enable the development and validation of promising CU inventions that are, or will become, suitable for commercialization. CU also makes Proof of Concept investments (POCi), which are early-stage seed investments in the form of convertible debt to enable further development of technologies that are the platform for a start-up company. CSU launched three Superclusters – Infectious Disease, Cancer, and Clean Energy – each of which provides funding of product development grants.

*Colorado has also made progress in building an entrepreneurial support infrastructure for start-up bioscience companies.*

Colorado has a growing number of organizations that provide business planning and management advice to entrepreneurial endeavors, some of which are targeted to the biosciences while others serve bioscience and other technology companies. These include the following:

- **Fitzsimons BioBusiness partners (FBBp)** – FBBp was originally formed by a number of sponsors including the Fitzsimons Redevelopment Authority (FRA), the CU Office of Technology Transfer, the Aurora Economic Development Council, and the Metro Denver Economic Development Corporation (Metro Denver EDC). It operates as part of FRA and has an advisory board that includes seasoned bioscience entrepreneurs and both in-state and out-of-state venture capitalists. FBBp helps prepare entrepreneurs to seek capital and links them to sources of early-stage capital. Members of the board serve as mentors to the entrepreneurs.
- **Boulder Innovation Center (BIC)** – BIC, a nonprofit organization created in January 2005, supports economic development by linking experienced entrepreneurs and business owners with early-stage companies to offer advice in areas such as business processes, industry dynamics, and pursuit of funding. BIC supports business development in a number of industries, including

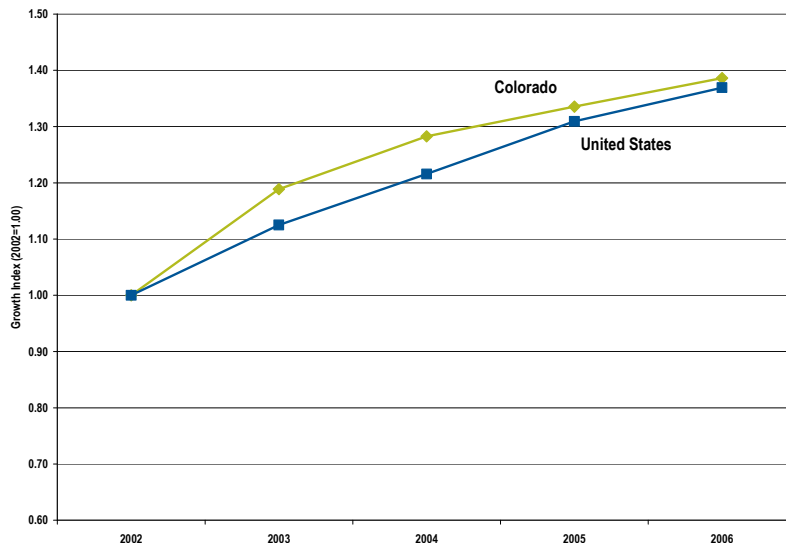
renewable energy/clean tech, bioscience, and nanotechnology, and supports commercialization of technologies originating from CU.

- **Rocky Mountain Innovation Initiative (RMI<sup>2</sup>)** – RMI<sup>2</sup> is a regional nonprofit organization formed to accelerate the success of high-impact science and technology-based companies in Northern Colorado. RMI<sup>2</sup> connects entrepreneurs with capital, academic and government institutions, professional service providers, and workforce talent. It operates the Fort Collins Innovation Center (formerly the Fort Collins Incubator Program) and the Loveland Innovation Center. RMI<sup>2</sup> launched the NoCo Angel Network in 2008 to bring together entrepreneurs looking for financing and private individuals interested in investing in technology start-ups.
- **Longmont Entrepreneurial Network (LEN)** – LEN provides programs and services for entrepreneurs in its center in Longmont. It maintains a large network of advisors who volunteer their time to help entrepreneurs by providing business expertise ranging from concept development and business planning to operations and management.

*Colorado's universities have demonstrated a strong commitment to achieving bioscience research excellence in crucial bioscience research areas and to facilitating the commercialization of discoveries.*

The 2003 Action Plan called for expanding Colorado's research base and building research excellence in the state's bioscience niches. The data show that Colorado's bioscience-related R&D expenditures grew 38.6 percent between 2002 and 2006, from \$292 million to \$405 million. This rate of growth was greater than the 36.9 percent national rate over the same time period (Figure 2). Of note, medical sciences R&D in Colorado grew tremendously by 72.4 percent from 2002 to 2006, compared with 37.4 percent growth nationally.

**Figure 2: Bioscience Academic R&D Growth, Colorado and United States, 2002–2006**



### Building Bioscience R&D Infrastructure

Additional activities that are planned or underway at Colorado's universities and research campuses include the following:

- **Colorado Initiative in Molecular Biotechnology (CIMB) at CU-Boulder** – CIMB is an effort of the faculty and leadership of CU-Boulder to build a community of world-class physical, computational, and biological scientists and engineers to solve complex

biomedical problems, catalyze the bioscience industry in Colorado, and provide an unsurpassed education for students in the basic biomedical sciences. A capital campaign is underway to raise \$200 million to support the initiative. Planning is also underway for a new Systems Biotechnology Building to bring together more than 60 faculty and 600 researchers in three primary units: the Biochemistry Division, Chemical and Biological Engineering Department, and the CIMB. The

\$113 million building is expected to be occupied by December 2009. CU has recruited Nobel Laureate Dr. Tom Cech to serve as Director of CIMB.

- **Colorado Biomedical Initiative** – The Colorado Biomedical Initiative is aimed at supporting collaboration between UC Denver’s strengths in the basic sciences and the clinical excellence found at the Health Sciences Center located on Anschutz Medical Campus. A capital campaign is planned to raise \$275 million to provide support for faculty chairs, fellowships, special programs, laboratory equipment, research, and research facilities. The overall focus of the initiative will be to support medical innovation, discovery, and commercialization of drugs and devices.
- **Research Infrastructure Growth at CSU Foothills Campus** – CSU continues to develop its infectious diseases research capabilities with the 2005 addition of the \$30 million Rocky Mountain Regional Biocontainment Laboratory. The lab, which meets Biosafety Level 3 requirements, complements the 2005 establishment of a National Institutes of Health (NIH)-funded Regional Center of Excellence for Biodefense and Emerging Infectious Diseases and the 2007 opening of the \$80 million Centers for Disease Control and Prevention Division of Vector-Borne Infectious Diseases Laboratory. In addition, CSU recently broke ground on a \$53 million Research Innovation Center (RIC), which will include 12 to 15 incubator labs and a biologics Good Manufacturing Practices (GMP) facility as part of its Foothills Campus Infectious Disease Research Complex.

In 2007, CSU formed CSU Ventures, Inc. within the CSU Research Foundation to house the enterprise arms of its three Superclusters™, *MicroRx*™ (2007), *NeoTREX*™ (2007), and *Cenergy*™ (2008). Each enterprise is independently staffed with new positions and represents an innovative model for partnering and licensing university research that is receiving national and international attention.

- **Completion of CSU’s Research Innovation Center (RIC)** – RIC, a 50,000-square-foot facility scheduled for 2010, will be a joint university/federal lab research complex with GMP laboratory space and dedicated space for public-private partnerships, addressing the great need for wet-lab space for start-ups in Northern Colorado. A similar project is planned with a cancer-related theme to leverage translational strengths found in the CSU Vet School’s Animal Cancer Center and the new Biomedical Engineering Program.
- **Construction of a New Science and Engineering Building at the University of Colorado at Colorado Springs (UCCS)** – The Science and Engineering Building, scheduled to open in late 2009, is the largest construction project in the history of UCCS. The \$53 million building will house larger and improved laboratory and classroom space for the Departments of Biology, Chemistry, Physics, and Mechanical and Aerospace Engineering and the College of Nursing and Health Sciences.
- **New Bioengineering Initiatives at CU-Boulder, CSU, and UC Denver** – CSU is offering new Ph.D. and M.S. degrees in Bioengineering starting in the Fall of 2008. A Center for Bioengineering is being formed at the UC Denver with the goal of creating a Department of Bioengineering within 5 years. The Department will have research and training links to CU-Boulder and UCCS.
- **Substantial Growth of National Jewish Health Planned During the Next 10 Years** – The hospital has hired 36 new faculty in the past 18 months and is investing in core labs. It has set up an innovation process that will allow doctors to bring innovations into the hospital system.
- **The University of Denver Committed to Building its Bioscience Research Base** – With an initial focus on biophysics, neurosciences, and aging, the University of Denver has identified

nanotechnology as one of its longer-range competencies, with plans to build a \$10 million nanotechnology facility within its planned new research building; hiring of faculty in nanobiotechnology is underway. The University of Denver is home to the Eleanor Roosevelt Institute, which conducts basic research in the neurosciences and in Down syndrome.

- **Development of Anschutz Medical Campus and Relocation of Hospitals to the Site** – The relocation of the University of Colorado Health Sciences Center, University of Colorado Hospital and The Children’s Hospital from downtown Denver to the former Fitzsimons Army Medical Center in Aurora has spanned the past decade, with major projects completed since 2003. These include the move and/or construction of all of the University of Colorado Hospital inpatient, outpatient and cancer pavilions, the Center for Dependency, Addiction and Rehabilitation, The Children’s Hospital, the Barbara Davis Center for Childhood Diabetes, the Lazzara Center for Oral and Facial Health, University Physicians, Inc. office building, and 800,000 square feet of administrative and education buildings. The completion of the first major interdisciplinary research building occurred in 2004, and completion of the second is slated for 2008. Total capital investment in the site is over \$2 billion. In November 2006, the University of Colorado portion of the campus was renamed Anschutz Medical Campus, in recognition of a series of gifts totaling more than \$91 million by The Anschutz Foundation. The Denver Department of Veterans Affairs Hospital will also relocate to the Fitzsimons site and will be completed in 2012. The campus, with an estimated total investment of \$5 billion upon completion, currently has 16,000 employees and is expected to reach 23,000 employees in 10 years and 43,000 at full build-out in 20 to 30 years.
- **Growth at Colorado Science +Technology Park at Fitzsimons** – Forest City Science and Technology Group, in partnership with the FRA, is developing the Colorado Science + Technology Park at Fitzsimons. The Park is adjacent to the Anschutz Medical Campus and Children’s Hospital. There are currently two buildings in the Park: Bioscience Park Center and Bioscience East, both of which house early-stage life science companies. The Park’s next 65,000-square-foot multitenant office and lab building is scheduled to begin construction in 2008.

## Moving Research Findings Into Commercial Applications

Both CSU and CU have made significant investments in their respective technology transfer and commercialization functions and expanded greatly their focus on facilitating the process of moving research discoveries into commercial products and applications. Bioscience company executives and other members of Colorado’s life science community interviewed for this Roadmap noted these changes as an area in which the greatest progress has been made since the 2003 Action Plan was adopted.

CSU created **CSU Ventures Inc.** in 2007 to better serve businesses interested in commercializing university-developed technology. CSU Ventures is a nonprofit corporation that houses CSU’s **Supercluster** business enterprises. CSU’s Superclusters, a new business development model for public-private partnerships and technology transfer, are organized around a major global challenge, uniting an academic arm (an interdisciplinary alliance of researchers, economists, and business experts) and an enterprise arm (a chief scientific officer, chief operating officer [COO], and tech transfer specialists reporting through CSU Ventures). The overarching goal is to move technologies more rapidly into the marketplace. To date, CSU has created three Supercluster business units: **MicroRx™**, focused on infectious diseases; **NeoTREX™**, focused on cancer diagnosis and treatment; and **Cenergy™**, focused on clean energy. CSU presently has 10 new full-time employees (FTEs),



with seven positions filled, working with the existing CSU Research Foundation's Technology Transfer Office, compared with only three individuals dedicated to technology transfer 3 years ago. In the past 2 years, invention disclosures have increased by 75 percent. Between 2002 and 2007, 18 new companies were formed around CSU technologies, 13 of which were in the biosciences.

CU has seen continued growth in its technology transfer activities. As a result, revenue attributed to technology transfer activities rose from a level of \$2.1 million in FY 2002–2003 to \$24 million in FY 2006–2007. During this 6-year period, the cumulative revenue created primarily from royalty based on sales of products protected by CU patents, but also including legal settlements, was \$113.5 million.<sup>3</sup> As discussed previously, approximately 10 bioscience companies annually are being launched based on CU-developed IP. Of the more than 250 invention disclosures submitted by CU researchers and faculty in FY 2007, 59 percent were in the biosciences. The CU Office of Technology Transfer takes a portfolio view of its technologies, developing roadmaps and tracking progress toward commercialization. This approach is fairly unique among university technology transfer centers.

Another development that will further accelerate the application of new discoveries in the marketplace and place Colorado among leaders in translational and clinical research was the selection of UC Denver to receive an NIH Clinical and Translational Science Award (CTSA). UC Denver received a \$76.1 million, 5-year NIH award to fund the **Colorado Clinical and Translational Science Institute (CCTSI)** in May 2008. The Institute will function as a comprehensive, integrated academic center that promotes research and education in clinical and translation science at UC Denver, at affiliated institutions, and in participating communities. Participants in the Institute include UC Denver's Schools of Medicine, Dentistry, Pharmacy, and Public Health, Graduate School, and College of Nursing; CU-Boulder; University of Colorado Hospital; Children's Hospital; Denver Health; National Jewish Health; Denver Department of Veterans Affairs Hospital; and Kaiser Permanente. CCTSI will focus on the following areas:

1. Training future researchers
2. Converting lab research to clinical use
3. Applying clinical lessons in communities
4. Discovering new methods and applying technologies to measure and analyze data
5. Advancing child and maternal research.

The creation of CCTSI positions Colorado to become a leader in translational medicine.

## Summary

Clearly, Colorado has greatly progressed in implementing the actions proposed in the 2003 Action Plan. This progress is evidenced by the growth of successful bioscience companies as well as high-value exits of several companies, emergence of a networked statewide bioscience community, recognition and support of the biosciences by state government, provision of new sources of PoC funding, emergence of entrepreneurial support infrastructure of start-up bioscience companies, growth of the academic bioscience research base, commitment to technology transfer and commercialization by universities, and continued development of the Anschutz Medical Campus and the Colorado Science + Technology Park at Fitzsimons. The next chapter examines Colorado's bioscience industry and R&D base.

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<sup>3</sup> University of Colorado, *Technology Transfer Office: Annual Report, Fiscal Year 2006–2007*.



# COLORADO'S BIOSCIENCE SECTOR

*In 2003, when the Colorado Bioscience Action Plan was developed, Colorado was feeling the impact of the downturn in the information technology (IT) sector. One reason for focusing on the biosciences was to diversify Colorado's technology industry base. At the time, Colorado had a significant foundation on which to build a bioscience cluster, including a significant academic bioscience R&D base and a growing number of bioscience companies. Today, Colorado's industry is maturing, with a critical mass of companies found in the state's leading metropolitan regions. The state's bioscience R&D base has also grown significantly, with research strengths across a wide number of bioscience areas. This chapter describes Colorado's current bioscience industry and research base.<sup>4</sup>*

## Colorado's Industry Growth

Colorado, from an industrial perspective, is growing its bioscience sector and refining its distinct niches. The state has a mature, specialized, and nationally ranked medical device and equipment subsector and a research, testing, and medical laboratories subsector emerging at a rapid rate. Colorado's metropolitan areas are leading national centers of bioscience activity and exemplify the benefits of growing a regional bioscience sector. The strong niche activities seen statewide have thrived in Colorado communities that attract and retain a nationally competitive talent base in bioscience R&D and bioproduct design. Colorado's universities and biomedical research institutions provide a core of premier research capability and a lengthy track record of successfully commercializing bioscience breakthroughs. The following are key findings with regard to trends in the growth of Colorado's bioscience industry sector during the 2001–2006 time period, the most recent period for which employment data are available.

### Colorado Bioscience at a Glance

Total Employment, 2006: **18,000**

Number of Establishments, 2006: **920**

Employment Growth 2001–2006: **5.5%**

Growth in Number of Establishments, 2001–2006: **27.9%**

Average Wages, 2006: **\$67,320**

Academic Bioscience R&D Expenditures, FY 2006: **\$405 million**

NIH Funding, 2007: **\$317 million**

**Colorado has a sizable and growing bioscience industry.** The state sector employed nearly 18,000 in 2006 and spanned 920 individual business establishments (see Table 1).<sup>5</sup> The number of bioscience establishments increased by 28 percent between 2001 and 2006, growing much more rapidly than the national rate of 16 percent, suggesting that employment will continue to increase as these establishments grow. Colorado's employment base results in a bioscience location quotient (LQ) of 0.83 or a statewide job

<sup>4</sup> This section of the report briefly summarizes findings from two detailed technical reports, *Colorado Bioscience Roadmap: Economic Analysis* and *Colorado Bioscience Roadmap: Core Competency Assessment and Identification of Technology Platforms*, both of which were completed in September 2008.

<sup>5</sup> The term “establishment” used throughout this analysis is not synonymous with a “company.” A firm or employer can have one or more establishments. An establishment is an economic unit, such as a farm, mine, factory, or store that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. CBSA estimates that the state's 920 bioscience establishments translate into approximately 460 bioscience companies.

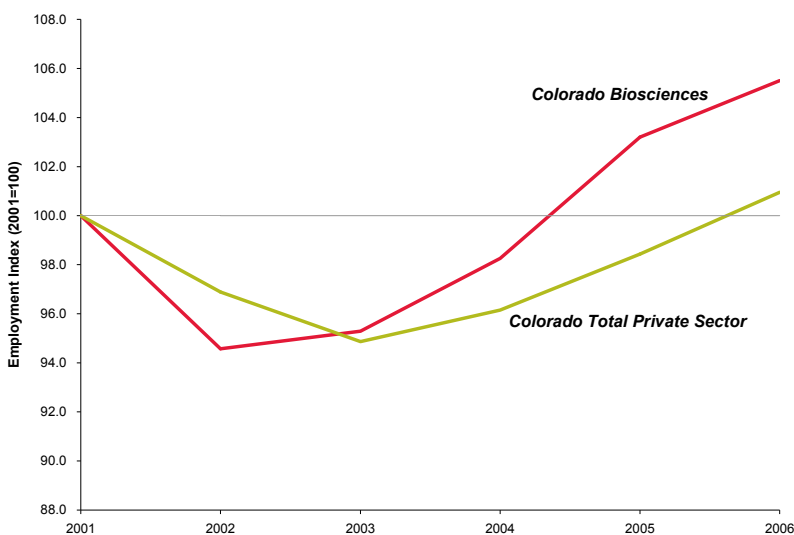
concentration that is 83 percent of the national average.<sup>6</sup> Colorado, while not considered to have a specialization in its overall bioscience sector, has distinct niches among the primary bioscience subsectors and strong clusters or pockets of activities among several of its major metropolitan areas.

**Table 1: Colorado and U.S. Bioscience Employment Metrics, 2001–2006**

Industry Subsector	2006 Establishments	Percent Change Estab, '01-06	2006 Employment	Percent Change Empl, '01-06	2006 Location Quotient
<b>Colorado</b>					
<b>Total Biosciences</b>	<b>920</b>	<b>27.9%</b>	<b>17,856</b>	<b>5.5%</b>	<b>0.83</b>
Agricultural Feedstock & Chemicals	26	15.4%	308	-28.0%	0.17
Drugs & Pharmaceuticals	56	3.7%	2,816	-4.4%	0.53
Medical Devices & Equipment	342	3.9%	8,782	-0.3%	<b>1.25</b>
Research, Testing, & Medical Labs	496	58.3%	5,949	25.6%	0.80
<b>United States</b>					
<b>Total Biosciences</b>	<b>42,910</b>	<b>15.7%</b>	<b>1,295,979</b>	<b>5.7%</b>	<b>N/A</b>
Agricultural Feedstock & Chemicals	2,183	3.8%	105,846	-6.1%	N/A
Drugs & Pharmaceuticals	2,654	1.9%	317,149	4.0%	N/A
Medical Devices & Equipment	15,215	0.3%	422,993	-0.9%	N/A
Research, Testing, & Medical Labs	22,857	32.7%	449,991	17.8%	N/A

Source: Battelle analysis of Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

**Figure 3: Employment Growth in Colorado Biosciences and Total Private Sector, 2001–2006**



Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

**Growth in bioscience employment greatly exceeded growth in total private sector employment in Colorado.**

Colorado's bioscience sector is growing, adding 5.5 percent to the statewide job base since 2001 (an 11.6 percent increase since 2002) and rapidly increasing total establishments by 27.9 percent during this same period.

Bioscience jobs are increasing much more quickly than jobs in the total private sector. Figure 3 illustrates this recent performance, and while both the biosciences and the overall private sector have rebounded well in recent years, the bioscience sector continues to

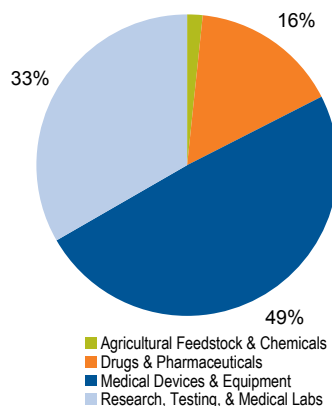
outpace overall job growth in Colorado. In general, this relationship reflects the strong national performance

<sup>6</sup> Location quotients are a common measure of the concentration of a particular industry in a state or region relative to the nation (reference area). The LQ consists of the ratio of the share of total regional employment that is in the particular industry and the share of total employment in the nation (reference area) that is in the particular industry. An LQ greater than 1.0 for a particular industry indicates that the region is relatively concentrated, whereas an LQ less than 1.0 signifies a relative under-representation. An LQ above 1.20 denotes employment concentration well above the national average. The minimum concentration threshold for declaring a regional specialization is a matter of judgment and varies somewhat in the relevant literature. In this analysis, regional specializations are defined by LQs of 1.2 or greater.



of the U.S. bioscience sector, which has grown by 5.7 percent during the 2001 to 2006 period, outpacing the national private sector that grew by 3.1 percent.

**Figure 4: Percent of Total Colorado Bioscience Employment by Subsector, 2006**



Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

Colorado has a diversified bioscience base with industry strengths in medical devices and equipment and research, testing, and medical laboratories. In Colorado, core bioscience activities center around the state’s large and specialized medical device and equipment subsector and its sizable and rapidly growing research, testing, and medical laboratories subsector. Medical device firms in Colorado employ approximately one-half of state bioscience workers (Figure 4). Research, testing, and medical laboratories employed one-third of all bioscience workers, a share that has risen from 28 percent since 2001. Colorado’s emerging research, testing, and medical laboratories subsector has outpaced job growth in the national sector, adding more than 25 percent to its employment base since 2001. Firms that manufacture drugs and pharmaceuticals also have a presence in the state, accounting for 16 percent of total sector jobs.

Colorado hospitals, though not included in the official industry definition of the biosciences in this examination of economic analysis, play a critical role in advancing biomedical R&D and have outpaced the U.S. hospital sector in job growth since 2001.

**Colorado is home to strong clusters of bioscience activity among its major metropolitan regions, each with its own distinct niche (Figure 5 and Table 2).**

- **Denver-Aurora**, which includes Adams County, Arapahoe County, Broomfield County, Clear Creek County, Denver County, Douglas County, Elbert County, Gilpin County, Jefferson County, and Park County, has a large and growing base of private bioscience firms and employment. The metropolitan region has a specialized and leading medical device subsector, and job growth in the biosciences has been especially strong since 2001 (up 17 percent). Its research, testing, and medical laboratories subsector grew significantly during this time period, with establishment growth of 68 percent and employment growth of 25 percent.
- **Boulder**, which includes only Boulder County, is a national leader in the biosciences, with an impressively diverse group of highly specialized subsectors. In fact, the region has specializations in three of the four bioscience subsectors, one of only 14 metropolitan statistical areas (MSAs) (out of 361 in the United States) to reach this distinction nationally. Boulder ranks among the top three mid-sized national metropolitan areas in overall bioscience jobs and relative job concentration and is the overall leader in medical device manufacturing among these same peer regions.
- **Fort Collins-Loveland**, which includes only Larimer County, has a highly concentrated and emerging regional bioscience sector. The metropolitan area boasts two subsector specializations – medical devices and equipment and research, testing, and medical laboratories. Since 2001, the region has added an impressive 37 percent to its bioscience employment base.
- **Colorado Springs**, which includes El Paso County and Teller County, has a sizable presence in the biosciences

**Denver-Aurora** ranks 19th among all U.S. metro areas in the size of its medical device sector.

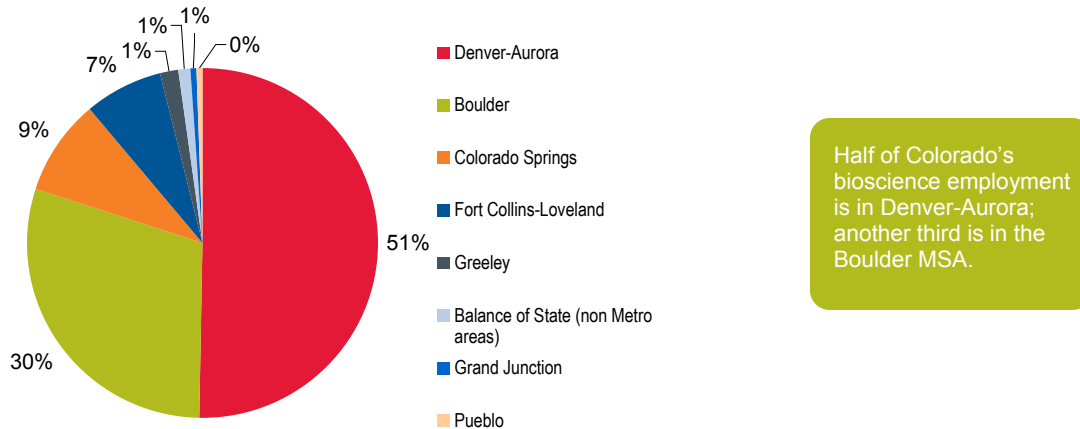
**Boulder** is one of only 14 MSAs in the United States to have a specialization in three of the four bioscience subsectors and ranks first in the nation in its concentration of employment in the medical device sector among medium-sized metro areas.

**Fort Collins** has a specialization in medical devices and research, testing, and medical labs.

**Colorado Springs** has a concentration in medical devices and equipment, but experienced some bioscience job loss between 2001 and 2006.

for a mid-sized region. The metropolitan area reflects and supports the state’s strengths in medical device manufacturing, where Colorado Springs has a greater-than-average concentration of jobs. The local bioscience sector is facing challenges, however, as it has contracted in recent years.

**Figure 5: Colorado Employment by Metropolitan Area, 2006**



Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

**Table 2: Colorado Bioscience Employment and Establishments by Metropolitan Area, 2002–2006**

Industry Subsector	2006 Establishments	Percent Change Estab, '01-06	2006 Employment	Percent Change Empl, '01-06	2006 Location Quotient
<b>Denver-Aurora MSA</b>					
<b>Total Biosciences</b>	<b>492</b>	<b>25.7%</b>	<b>8,971</b>	<b>17.1%</b>	<b>0.78</b>
Agricultural Feedstock & Chemicals	8	32.6%	17	-75.6%	0.02
Drugs & Pharmaceuticals	23	-28.4%	1,195	-2.0%	0.44
Medical Devices & Equipment	180	-2.8%	4,579	19.8%	<b>1.21</b>
Research, Testing, & Medical Labs	279	68.0%	3,179	24.7%	0.78
<b>Boulder MSA</b>					
<b>Total Biosciences</b>	<b>121</b>	<b>2.2%</b>	<b>5,291</b>	<b>-7.4%</b>	<b>3.57</b>
Agricultural Feedstock & Chemicals	1	-64.2%	42	17.4%	0.33
Drugs & Pharmaceuticals	14	-16.1%	1,366	4.9%	<b>3.97</b>
Medical Devices & Equipment	42	-4.8%	2,537	-24.6%	<b>5.24</b>
Research, Testing, & Medical Labs	64	16.8%	1,347	33.1%	<b>2.56</b>
<b>Colorado Springs MSA</b>					
<b>Total Biosciences</b>	<b>109</b>	<b>22.2%</b>	<b>1,612</b>	<b>-15.5%</b>	<b>0.69</b>
Agricultural Feedstock & Chemicals	2	-24.1%	26	-49.1%	0.13
Drugs & Pharmaceuticals	4	203.1%	120	-3.2%	0.22
Medical Devices & Equipment	39	-0.6%	802	-1.8%	1.05
Research, Testing, & Medical Labs	64	38.7%	664	-27.5%	0.80
<b>Fort Collins-Loveland MSA</b>					
<b>Total Biosciences</b>	<b>68</b>	<b>50.2%</b>	<b>1,309</b>	<b>36.6%</b>	<b>1.12</b>
Agricultural Feedstock & Chemicals	3	58.1%	21	45.2%	0.21
Drugs & Pharmaceuticals	8	184.0%	90	-59.6%	0.33
Medical Devices & Equipment	28	24.6%	647	7.2%	<b>1.69</b>
Research, Testing, & Medical Labs	29	60.1%	551	370.9%	<b>1.33</b>

Note: Numbers in red indicate location quotients (LQs) greater than 1.2, which denotes employment concentration significantly above the national average and is referred to as a “specialization.”

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

The Colorado bioscience sector, similar to trends nationally, pays average wages to its workers well above those earned by their counterparts in the rest of the private sector. In 2006, Colorado bioscience workers earned, on average, just over \$67,000 per year. This compares with \$43,664 for the average overall private sector wage (Table 3). The premium paid to these workers – at nearly \$24,000 (or 54 percent more) – is similar to the national premium (nearly \$29,000 or 61 percent more). In fact, each major bioscience subsector pays, on average, more than the average private sector wage. Workers in research, testing, and medical laboratories and those in drugs and pharmaceuticals are the highest paid in the biosciences, with each earning an average of roughly \$75,000 per year in 2006.

**Table 3: Average Annual Wages for Colorado Biosciences and Other Major Industries, 2006**

Major Industries & Bioscience Subsectors	Avg. Annual Wages, 2006
Management of Companies and Enterprises	\$ 101,806
Information	\$ 76,257
Research, Testing, & Medical Laboratories	\$ 74,722
Drugs & Pharmaceuticals	\$ 74,707
Professional, Scientific, and Technical Services	\$ 71,544
<b>Total Biosciences</b>	<b>\$ 67,320</b>
Finance and Insurance	\$ 65,095
Medical Devices & Equipment	\$ 60,615
Manufacturing	\$ 54,865
Agricultural Feedstock & Chemicals	\$ 47,980
<b>Total Private Sector</b>	<b>\$ 43,664</b>
Construction	\$ 43,215
Real Estate and Rental and Leasing	\$ 41,071
Health Care and Social Assistance	\$ 40,205
Arts, Entertainment, and Recreation	\$ 29,592
Retail Trade	\$ 25,849

It is clear that Colorado is home to a vibrant and growing bioscience industry sector, with an established niche in medical devices and equipment and a developing niche in research, testing, and medical laboratories. The state has leading metropolitan areas in specialized subsectors, with Denver-Aurora being its largest and Boulder being its most highly specialized and nationally ranked. Colorado bioscience firms benefit from a strong base of regional talent and both academic and biomedical research strengths. These strengths are discussed below.

Source: Battelle analysis of BLS, QCEW data from the Minnesota IMPLAN Group.

## Colorado's Bioscience Research Strengths

The 2003 Colorado Action Plan identified bioscience research areas in which Colorado had signature research strengths, competitive advantages, and unique assets that could be leveraged for growing the state's bioscience research base, achieving technology commercialization, and ultimately driving economic growth. The 2003 Action Plan identified strengths and opportunity areas ranging across a broad spectrum of the biosciences, including cancer treatment, animal sciences, plant biotechnology, psychiatry, and many others.

While the 2003 Colorado Action Plan provided a snapshot of the state's position in core research focus areas, the global bioscience landscape has evolved and continued investments have been made in Colorado's bioscience capacities. Together, these changes call for a fresh assessment of the state's position and current opportunities for bioscience-driven economic development. Battelle conducted a core competency assessment that confirmed the strength of the majority of the core competencies identified in 2003 and identified several new core competencies. The findings from this analysis were used to further refine the technology platforms that appear to offer the greatest opportunities for the future growth of Colorado's bioscience cluster in terms of research leading to commercial potential and opportunities.

## Colorado's Bioscience Research Core Competencies

To understand the potential for bioscience development in Colorado, it was necessary to undertake a rigorous analysis of the existing bioscience research core competencies found across the base of universities in the state. As defined by Gary Hamel and C. K. Prahalad in *Competing for the Future*,<sup>7</sup> a "competence" is a bundle of skills and technologies representing the sum of learning across individual skill sets and organizational units.

<sup>7</sup> Hamel, G., and C. K. Prahalad. *Competing for the Future*. Harvard Business School Press: Boston, MA, 1994, pp. 90 and 217.

Research core competencies at a university or independent research institution 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 were required to help identify an institution's current position and areas of focus that may contribute or lead to Colorado's future bioscience growth.

Using both quantitative and qualitative methods, Battelle has developed a rigorous approach for assessing the core competencies of research institutions. Battelle's quantitative assessment involves a unique cluster analysis of federal grant awards and patents, an analysis of publications activities, a review of major competitively funded research programs and centers, and a review of reputational surveys of Colorado's institutional position in bioscience-related research and clinical fields. This assessment revealed the following.

"Core competencies are the gateways to future opportunities. Leadership in a core competence represents a potentiality that is released when imaginative new ways of exploiting that core competence are envisioned."

Hamel and Prahalad,  
*Competing for the Future*

Colorado has a diversified bioscience research base with primary, secondary, and cross-cutting core competencies in many areas of the biosciences, as shown in Figure 6. *Primary* core competencies are those characterized by a significant research base including multiple well-funded scientists and clinician researchers, recognized clinical expertise, and the presence of commercial entities with R&D or production facilities working in the delivery of goods or services in the field. *Secondary* core competencies have a smaller but still significant research base, lower level of clinical activity, and fewer commercial entities or have a niche focus of activity rather than a broad focus across the field. *Cross-cutting* competencies represent broad areas of research that underpin or are supportive of multiple fields.

Colorado has developed core competencies in five new areas since 2003:

- Hematology
- Medical Imaging
- Urology/Nephrology
- Orthopedics
- Translational Medicine.

### Paths to Bioscience Development: Translating Core Competencies into Technology Platforms

Colorado's core competencies in the biosciences are the foundations on which the state will build its position and reputation in the global bioscience-based economy. But, the translation of these core competencies – and areas of significant industry activity – into broader technology platforms (Figure 7) will enable Colorado to exploit existing and emerging market opportunities.

Technology platforms are broad, applications-oriented, strategically chosen areas that offer the potential to realize significant gains in economic development. They should correspond to the development of technologies in a favorable time frame and in multiple substantial, growing markets and possibly evolve into or generate new technology platforms. Focusing on them can accelerate technology development, foster effective collaboration and partnerships, raise public awareness of the global issues they address, and stimulate investment in R&D. And, in the long term, implementation of a technology platform can produce sustainable competitiveness for the region by stimulating innovation, overcoming the barriers to the deployment of new technologies, and generating economic growth and expansion.

Figure 6: Colorado's 2008 Research Core Competencies\*

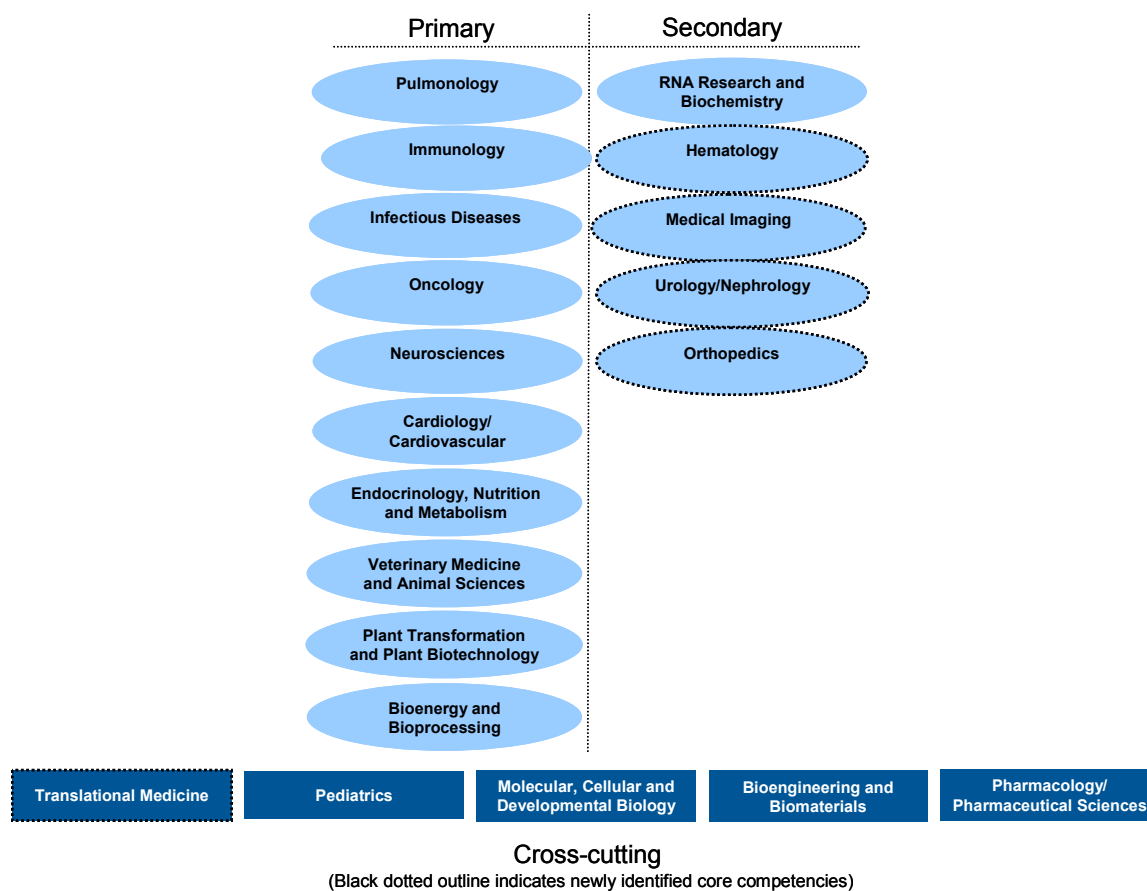
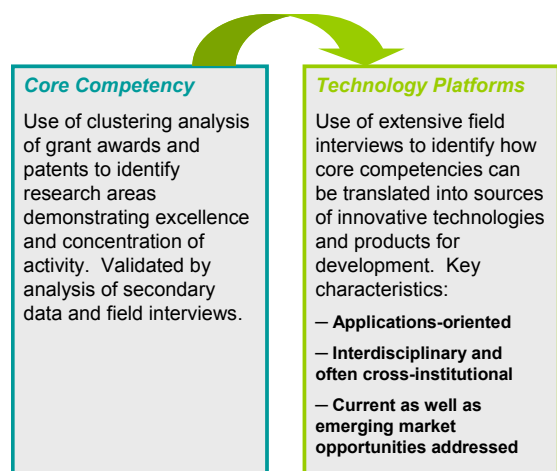


Figure 7: Translation of Core Competencies Into Technology Platforms



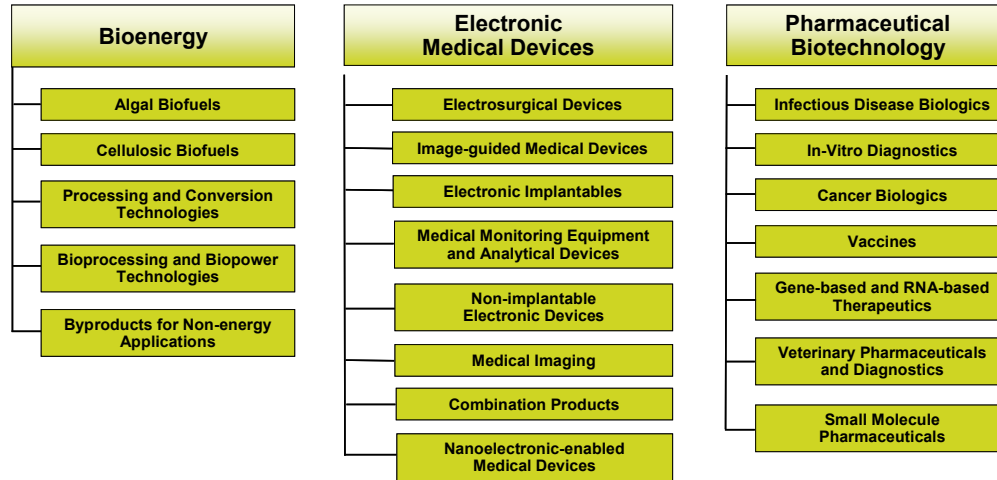
Identification of technology platforms requires the consideration of several criteria:

- **Opportunities drawing upon multiple core competencies and organizations.** The technology platform should address market opportunities that transcend multiple core competencies and organizations, ensuring that Colorado's bioscience research base is a fertile, multidisciplinary, cross-cutting, and collaborative research environment, rather than a collection of stand-alone research strengths.
- **Presence of existing or emerging industry connections.** The technology platform should align institutional research strengths with local industries, creating new linkages and strengthening existing connections.
- **Opportunity for external funding.** The technology platform should relate to pressing issues or needs and thus be likely to attract major external R&D funding and investment.

- **Limited competition from other states or regions.** A successful technology platform builds on specific competitive advantage such as geography, market base, tacit knowledge base, exclusive resources, or policies.

Based on these criteria, three technology platforms in the biosciences are identified for Colorado. These platforms do not correspond to each and every promising opportunity in the biosciences, but represent the broad areas where Colorado has the greatest likelihood of achieving a leadership position in the biosciences based on research strengths, industry activity, development potential, and competitive advantages. Figure 8 shows the technology platforms and examples of promising applications.

**Figure 8: Colorado’s 2008 Bioscience-Related Technology Platforms and Key Applications**



While other significant opportunities certainly exist that do not fall under these three broad headings, these three are considered the most inclusive of the opportunities where Colorado can build upon its growing base of research competencies, take advantage of existing and emerging market opportunities, and establish a stronger national reputation as a leader in the biosciences.

## Summary

Colorado has a growing bioscience industry base and very strong bioscience research capabilities. Colorado has the potential to become a truly world-class leader by working across institutions to advance its bioenergy, electronic medical device, and pharmaceutical biotechnology platforms. Its growing bioscience industry base provides the necessary private interests and capacities to turn this research into commercial opportunities around these identified platforms.

# COLORADO'S COMPETITIVE POSITION: ADDRESSING GAPS

*While Colorado has made great progress since 2003, gaps remain that hinder the growth and development of the state's bioscience sector and its positioning in the increasingly global economy. Chief among these are a continuing need for additional sources of early-stage risk capital and a more robust technology commercialization and entrepreneurial support network with sufficient financing. Colorado, while a very entrepreneurial state, still faces some challenges in meeting the talent needs of its start-up and emerging bioscience companies and the investment needs of the state's bioscience research infrastructure. This chapter discusses each of these areas.*

## Risk Capital

### *Why It's Important*

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 bioscience companies, at least 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. So, in addition to the difficulty of obtaining translational research and precommercialization funding, firms are facing a gap at the start-up phase. Figure 9 shows the necessary activities, financing sources, and levels of investment for technology companies at various stages of their development.

**Figure 9: Bioscience Company Financing Needs**

	Concept	Translational Research/ Precommercialization	Pre-seed/Seed	Early-Stage	Growth
ACTIVITIES	Conduct R&D Identify discoveries with possible commercial potential	Assess potential of technology Identify market Develop prototype Test and validate Demonstrate proof of concept at lab scale Protect IP Optimize engineering License or form business	Establish business function Secure initial financing	Prepare business strategy Put serial management team in place Secure follow-on financing Begin initial sales and marketing	Begin full-scale production Staff up for sales and marketing
FINANCING SOURCES	Conventional peer-reviewed federal grant support	<ul style="list-style-type: none"> <li>• Within university: Grants funded with university, State, or industry dollars</li> <li>• Nonuniversity: Grants funded by public and philanthropic support</li> <li>• SBIR I</li> </ul>	<ul style="list-style-type: none"> <li>• Friends and family</li> <li>• Pre-seed/seed funds</li> <li>• Angel investors</li> <li>• SBIR II</li> </ul>	<ul style="list-style-type: none"> <li>• Early seed-stage venture capital</li> <li>• Publicly supported investment funds</li> </ul>	<ul style="list-style-type: none"> <li>• Venture funds</li> <li>• Equity</li> <li>• Commercial debt</li> <li>• Industry (strategic alliances, mergers, and acquisitions)</li> </ul>
LEVEL OF INVESTMENT	Varies	\$50,000 to \$500,000	Up to \$1 million	\$1 million to \$2 million	> \$2 million

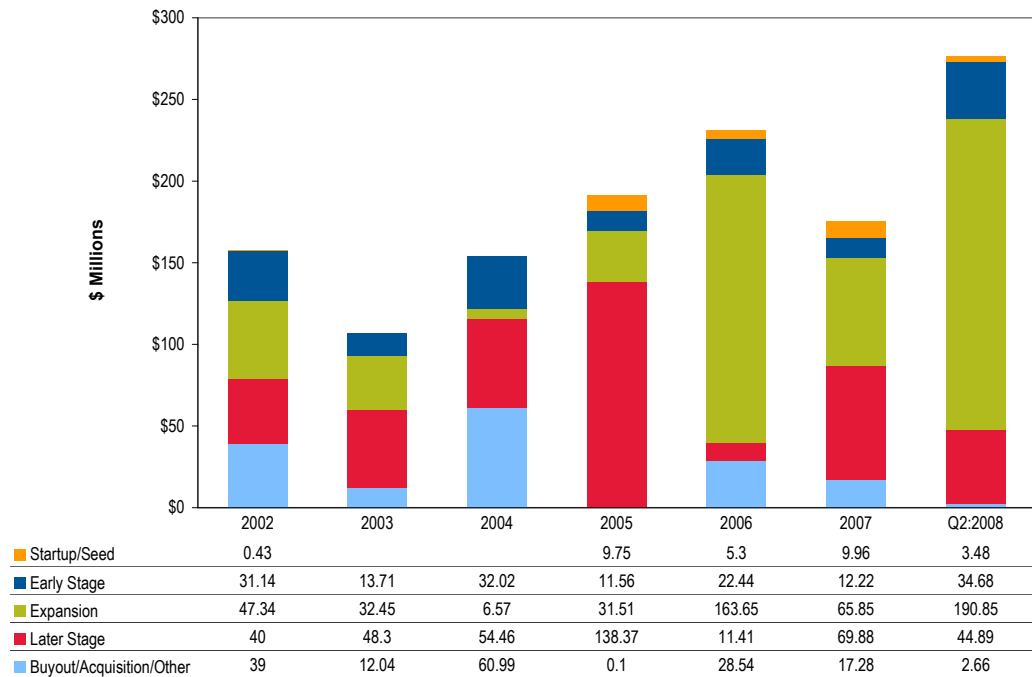
### Colorado's Situation

**Colorado consistently ranks among the top five states for venture investment and ranked 11th among the states in bioscience venture capital investments for the 2002–2007 time period.**

Approximately \$1.3 billion was invested in Colorado bioscience companies between 2002 and the second quarter of 2008, with about \$200 million being invested annually during the past few years. More than \$276 million was invested in Colorado life science companies during the first two quarters of 2008, with Range Fuels accounting for \$158 million of the total (Figure 10).



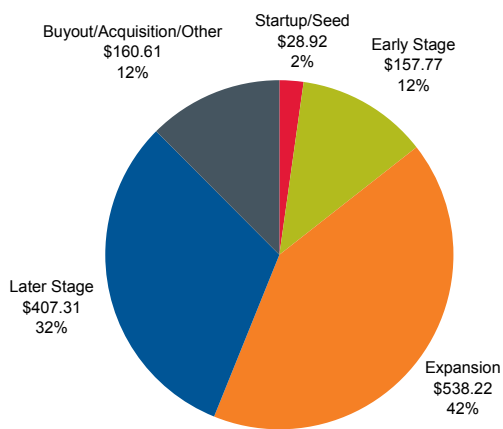
**Figure 10: Colorado Biosciences – Venture Capital Investments by Year and Stage, 2002–Q2 2008**



Source: Battelle analysis of Thompson Venture Xpert database.

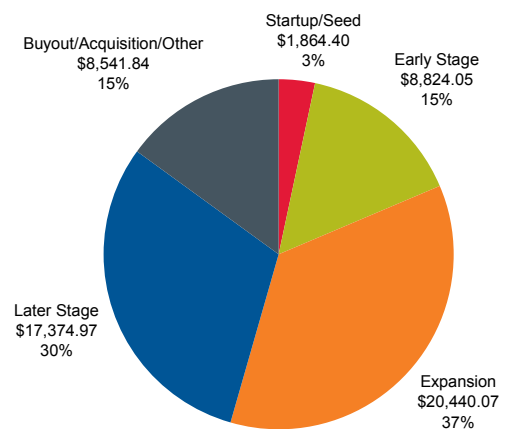
The majority of the investments made in life science companies have been expansion and later-stage investments. Only 14 percent of the dollars invested in Colorado bioscience firms were invested at the start-up/seed or early-stage phases during the 2002 to second quarter of 2008 time period (Figure 11). At the national level, 18 percent was invested in start-up/seed and early-stage deals (Figure 12); in leading bioscience states, the percentage invested at the start-up/seed and early stages is even higher, with 20 percent in California, 23 percent in Maryland, 26 percent in North Carolina, and 27 percent in New Jersey.

**Figure 11: Colorado Bioscience Venture Investments by Stage, 2002–Q2 2008 (millions of dollars)**



Source: Battelle analysis of Thompson Venture Xpert database.

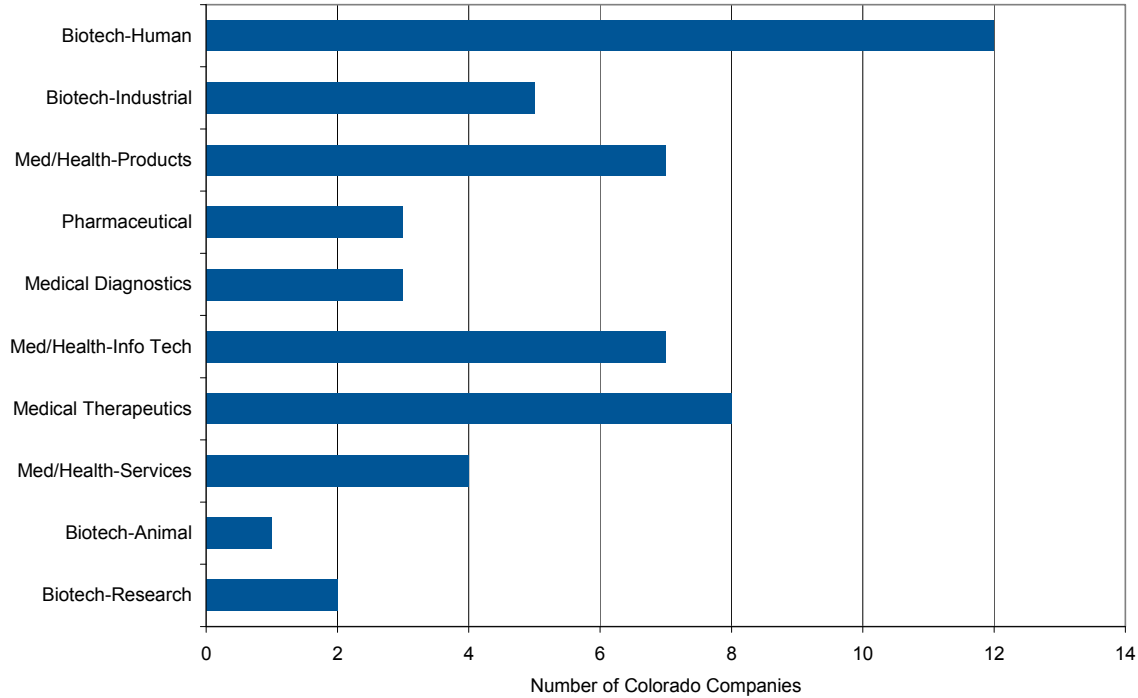
**Figure 12: U.S. Bioscience Venture Investments by Stage, 2002–Q2 2008 (millions of dollars)**



Source: Battelle analysis of Thompson Venture Xpert database.

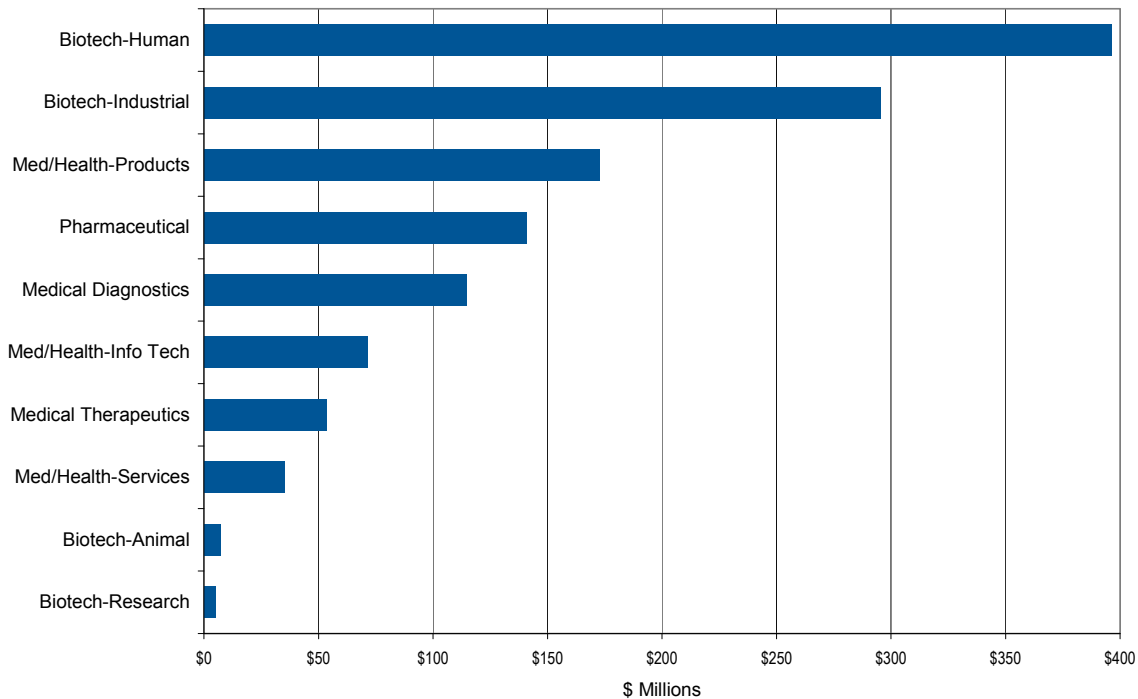
While medical therapeutics and medical diagnostics firms received a significant number of investments as measured by number of deals, the two areas that dominated in terms of receiving venture capital dollars were human and industrial biotechnology (Figures 13 and 14).

**Figure 13: Colorado Bioscience Companies Receiving Venture Capital Investments by Segment, 2002–Q2 2008**



Source: Battelle analysis of ThompsonVenture Xpert database.

**Figure 14: Colorado Bioscience Venture Capital Investments by Segment, 2002–Q2 2008**



Source: Battelle analysis of Thompson Venture Xpert database.

While Colorado has some strong local venture firms or national firms with Colorado operations, 80 percent of venture dollars invested in Colorado bioscience companies historically has come from out-of-state venture firms, suggesting that Colorado is producing a solid flow of attractive new venture opportunities.

Colorado bioscience companies are succeeding in attracting venture capital investments, and the state and its universities have undertaken a number of initiatives to provide early-stage risk capital for bioscience companies; but, a gap still remains at the pre-seed/seed stage of development. Additional local venture funds willing to invest in bioscience companies will be needed to support the state's bioscience sector as it continues to mature and grow.

#### **Colorado Venture Funds That Invest in the Biosciences**

- Aweida Venture Partners
- Boulder Ventures
- High Country Ventures
- Morgenthaler Ventures
- Quest Capital Partnership
- Sequel Venture Partners

## **Entrepreneurial Support**

### ***Why It's Important***

Supporting entrepreneurs and the growth of entrepreneurial companies must be a critical component of any state's or region's strategy to accelerate the growth of its bioscience economy. The resources that they need include management talent, technology, capital, professional expertise, and a host of other services. They often need assistance in determining economic feasibility and identifying markets and distribution channels. They may also need access to specialized equipment and laboratories and to expertise to solve technical issues that arise during product development. They must be able to recruit essential personnel and have access to pre-seed capital.

Support services that bioscience entrepreneurs value include business mentoring by successful serial bioscience entrepreneurs; in-depth counseling and advice to make the entrepreneur ready to present plans before angel and other informal investors; access to capital sources at the pre-seed, seed, and later stages; and help in forming a business team of managers with commercial vision. Bioscience chief executive officers (CEOs) also often need advice in finding laboratory space and dealing with regulatory and other issues that are specific to the bioscience sector.

### **Colorado's Situation**

Colorado is one of only 11 states that have an entrepreneurial support program, FBBp, specifically targeted to the biosciences. Colorado has additional programs, including CSU Ventures, BIC, LEN, RMI<sup>2</sup>, and various incubators, that provide support to entrepreneurs and start-up companies; but, most of these efforts have limited resources and often focus on a specific geographic area. While Colorado has a number of organizations that provide assistance to entrepreneurs and start-up companies, including bioscience companies, these programs are not at a scale found in best-practice programs and are hampered by the lack of funds that can be used to invest in start-up companies. Entrepreneurs and CEOs interviewed for this Roadmap continue to point to the need for a more in-depth support infrastructure that would provide mentoring and services for start-up and emerging bioscience companies.

## Talent

### Why It's Important

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

There is also a strong demand on bioscience workers to be lifelong learners who readily pick up new skill sets. Critical skill shortages can emerge quickly in the biosciences and pose major impediments to industry growth in particular niche areas. For example, developing new “biologic” drugs requires new biopharmaceutical production technologies and skills. Bioscience industry analysts at McKinsey and Company point out the impact of workforce gaps for this growing area of biotechnology: “What is less well understood is the biologics-manufacturing talent shortfall: the industry faces a looming shortage of the highly trained people needed to design, build and operate facilities. Experienced process-development scientists and engineers, validation engineers, quality assurance personnel and plant managers are already in short supply.”<sup>8</sup> These same dynamics can be true in other niches, from medical devices to health care delivery.

#### Factors Driving Bioscience Workforce Needs

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

#### New Bioscience Educational Offerings

- The University of Georgia’s College of Pharmacy now offers a clinical trials design and management certificate program and a pharmaceutical and biomedical regulatory affairs graduate certificate program
- The University of Medicine and Dentistry of New Jersey offers a postgraduate certificate in stem cell research, and the Robert Wood Johnson Medical School offers a master’s degree in clinical and translational sciences
- A new multi-institutional Graduate School of Biomedical Sciences has been launched in Maine

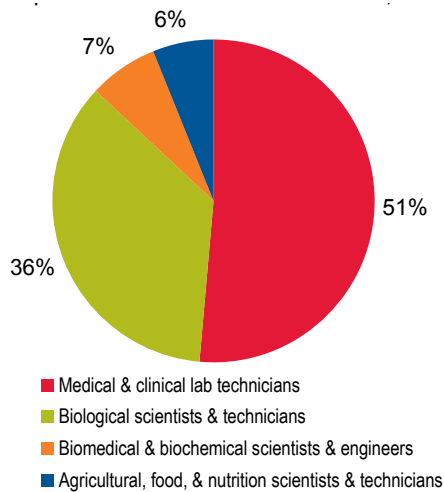
States have become very active in addressing the talent needs of the bioscience sector. Across the board, states are implementing new program offerings at all levels of education, including K-12, community college, undergraduate, and graduate; new programs combining business with biosciences; and new types of degree offerings to address the need for people with expertise in regulatory affairs and clinical trials. New bioscience 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 biosciences industry to develop career pathways in the biosciences, offering programs to equip teachers with bioscience skills and knowledge, and encouraging existing workers to retrain for careers in the biosciences.

<sup>8</sup> Mallik, A., G. Pinkus, and S. Sheffer. “Biopharma’s Capacity Crunch,” *The McKinsey Quarterly 2002 Special Edition: Risk and Resilience*. McKinsey and Company, 2002, pp. 9–11.

## Colorado's Situation

**Colorado's bioscience workforce mirrors the U.S. bioscience workforce in terms of occupational composition.** Colorado employs 10,780 workers in jobs that are considered highly related to core bioscience industry activity. As in other industries, a large technician workforce facilitates the innovative activities of a highly specialized scientific workforce (Figure 15).

**Figure 15: Colorado Bioscience Workforce by Occupations, 2007**



Source: U.S. BLS, Occupational Employment Statistics (OES) survey data, 2006.

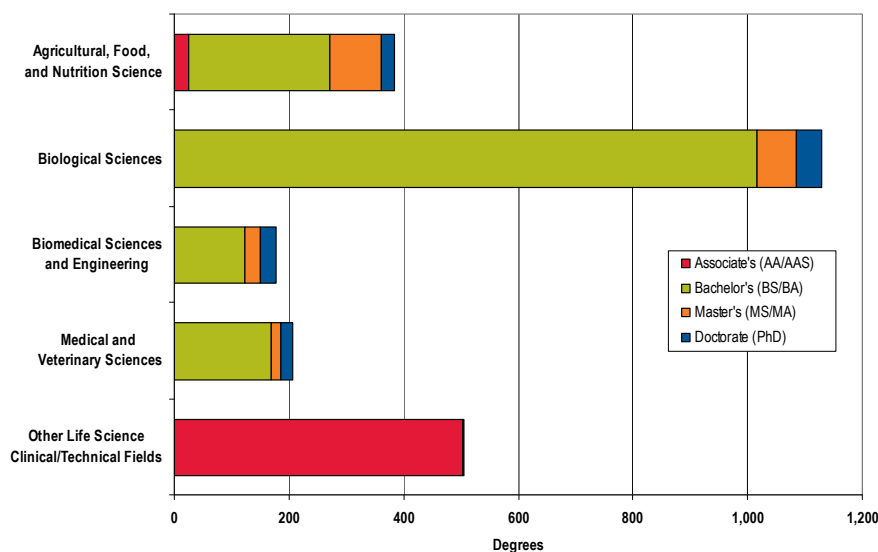
Overall, all Colorado occupations are expected to grow 2.7 percent through 2015, according to the projections of the Colorado Department of Labor. Six bioscience occupations are expected to grow more rapidly:

- Medical and clinical technologists
- Medical and clinical technicians
- Medical scientists
- Biomedical engineers
- Microbiologists
- Animal scientists.

In general, the bioscience occupations expected to grow rapidly in Colorado are those that require the most education and technical skills.

Colorado's post-secondary institutions are producing a strong base of graduates with life science degrees; however, most of these are at the bachelor's level. Yet, people with associate's and doctorate degrees supply much of the specialized bioscience technician and scientist occupations (Figure 16).

**Figure 16: Colorado Bioscience Higher-Education Degrees Awarded, 2006**



Source: National Center for Educational Statistics, Integrated Postsecondary Education Data System (IPEDS), 2006.

Colorado has begun to take some actions to address bioscience workforce needs. The Metro Denver EDC received a 4-year, \$15 million Workforce Innovation in Regional Economic Development (WIRED) grant to support initiatives aimed at developing a workforce with science, technology, engineering, and mathematics (STEM) skills to support the region's fast-growing technology industries, one of which is the biosciences. The initiative includes nine counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld.

While Colorado is graduating students in the biosciences and embarking on initiatives to meet future bioscience workforce needs, there are still areas that need to be addressed. Interviewees suggested that Colorado has the following:

- A growing cadre of serial entrepreneurs – but, senior-level executives with experience in growing bioscience companies still must often be recruited
- Excellent technical workers – but, more will be needed as the bioscience cluster continues to grow
- A shortage of regulatory affairs workers and medical directors
- An insufficient number of high school students studying STEM fields to meet future workforce needs
- A supply of bioscience graduates who lack industry experience.

In Academic Year 2006, Colorado's higher-education institutions generated 2,400 total degrees spanning associate's level through Ph.D. Colorado ranks 21st among all states in bioscience higher-education degrees awarded.

## Research Infrastructure

### *Why It's Important*

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

Bioscience 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.

### **Colorado's Situation**

One of the gaps noted in the 2003 Action Plan was the lack of sustained state investment in higher education. Not only has this issue not been addressed, but state funding for higher education has declined since 2003. A report prepared by the National Center for Higher Education Management Systems for the Colorado Commission on Higher Education in 2007 found that funding for higher education in Colorado trails the average of college and university peers by more than \$832 million in annual funding, with Colorado institutions of higher education receiving only 63 percent of the funding of their peers.<sup>9</sup>

Despite this funding gap, Colorado's universities and research institutions are making investments in faculty and facilities as noted earlier in "Colorado's Recent Key Accomplishments" chapter of this Roadmap. Significant investments in higher education and in research infrastructure will be needed if Colorado is to compete nationally and globally in the biosciences.

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<sup>9</sup> *Colorado Higher Education Finance Study*. Prepared for the Colorado Commission on Higher Education by the National Center for Higher Education Management Systems, May 2007.

## Crucial Areas to Address Moving Forward

Colorado clearly has made strides in creating an environment that is supportive of the biosciences and is seeing its industry sector approaching critical mass. But, certain areas will require significant future investment if Colorado is to become a leading center of the biosciences. Moving forward, Colorado will need to

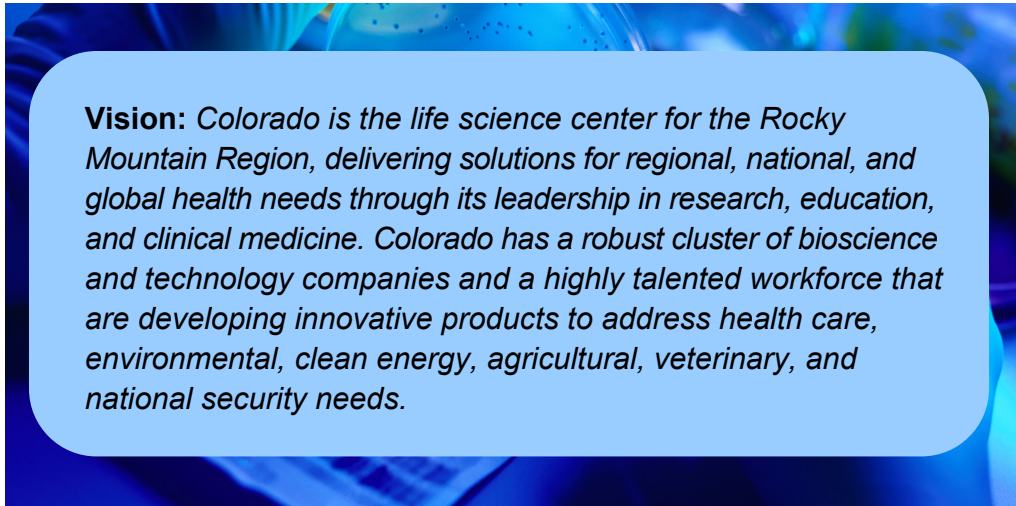
- Continue to implement actions to increase the availability of capital at each stage of investment cycle for bioscience companies;
- Develop a seamless bioscience technology commercialization network that provides support to bioscience entrepreneurs, start-ups, and emerging bioscience companies;
- Ensure that Colorado is developing, attracting, and retaining a population with the skills and education needed to support the bioscience sector; and
- Invest in the state's bioscience research infrastructure to keep Colorado and its researchers at the cutting edge of bioscience research and the application of discoveries in the marketplace.

This Roadmap lays out a vision for Colorado's bioscience future and proposes a set of strategies and actions to accomplish that vision.





# COLORADO'S BIOSCIENCE FUTURE



**Vision:** *Colorado is the life science center for the Rocky Mountain Region, delivering solutions for regional, national, and global health needs through its leadership in research, education, and clinical medicine. Colorado has a robust cluster of bioscience and technology companies and a highly talented workforce that are developing innovative products to address health care, environmental, clean energy, agricultural, veterinary, and national security needs.*

## Strategies and Actions

Table 4 (continued on next page) lists five strategies and 16 actions proposed to achieve Colorado's bioscience vision.

**Table 4: Proposed Strategies and Actions in Colorado Bioscience Roadmap 2008**

	Strategy	Action
STRATEGY 1	<i>Ensure availability of capital for bioscience companies at all stages of their development</i>	Action 1: Use tax credits to encourage investment in early-stage capital and bioscience companies
		Action 2: Explore options for enacting a refundable or transferable R&D tax credit for bioscience companies and expand through existing biotechnology sales and use tax credit to medical device companies
		Action 3: Continue and increase funding for the Bioscience and Life Sciences Fund (HB 08-1001) and allocate the additional funds for investments in bioscience companies
		Action 4: Undertake activities to make out-of-state venture capital funds aware of opportunities in the Rocky Mountain region
		Action 5: Explore options to create a \$250 million Fund of Funds with an emphasis on seed and early-stage funds

	Strategy	Action
STRATEGY 2	<i>Create a robust technology commercialization infrastructure in Colorado to rapidly move bioscience discoveries into the marketplace</i>	Action 6: Add bioscience capacity to local business development and entrepreneurial support networks
		Action 7: Establish a Bioscience Executive Corps to serve as mentors to start-up bioscience companies
		Action 8: Create a Colorado Drug, Diagnostic, and Device Development Institute
STRATEGY 3	<i>Ensure that Colorado is attracting, retaining, and producing individuals with the skills needed to meet future bioscience workforce needs</i>	Action 9: Create and fund a high school science teacher externship program
		Action 10: Establish a Bioscience Industry Fellows Program to place graduate and postdoctoral students in emerging bioscience companies
		Action 11: Continue to expand efforts to provide business and entrepreneurial education to bioscience students and to increase educational offerings to address critical skill needs
		Action 12: Create a nonprofit CBSA Foundation to develop and support bioscience programs to ensure that Colorado has the talent to meet the future workforce needs of the state's bioscience sector
STRATEGY 4	<i>Promote Colorado's position as a leading bioscience center</i>	Action 13: Ensure that the Governor's Office of Economic Development and International Trade continues to maintain dedicated bioscience staff
		Action 14: Develop and implement a bioscience branding and marketing strategy and communications campaign
STRATEGY 5	<i>Ensure Colorado's bioscience future by making a long-term commitment to support the development of the bioscience sector</i>	Action 15: Continue to support ongoing bioscience development projects and fund new ones as needed, including Anschutz Medical Campus, Colorado Science + Technology Park, CIMB, CSU Superclusters, and Renewable Energy Collaboratory
		Action 16: Identify revenue sources and create a fund to support bioscience policies, programs, and infrastructure investments in the long term

Each strategy and action is discussed below. Each action includes an estimate of the resources that would be required to implement the strategy, the level of importance, and the proposed time frame for implementation. Immediate actions should be undertaken in the next 12 months. Short-term actions should be undertaken in 1 to 3 years, and mid-term actions should be undertaken in 3 to 5 years.

## Rationale

One characteristic shared by leading bioscience states and regions is that they are home to a robust capital community that is both oriented toward early-stage investment and committed to local investment. It is critical to have local pre-seed, seed, and venture capital funds with experience investing in bioscience companies. Fortunately for Colorado, several local venture funds have supported the development of many of the state's successful bioscience companies. But, the funds based or with a presence in Colorado are small and can invest in a limited number of deals.

As Colorado's industry matures, its risk capital market must be able to address the continuum of capital needs from prototype through seed to later-stage formal venture financing. Five actions are proposed to ensure that Colorado bioscience companies will have access to capital at each stage of development. These actions, as discussed in the following sections, include using tax policy to encourage investment by angel investors; enacting a refundable or transferable R&D tax credit for bioscience companies; continuing to fund commercialization and PoC; marketing Colorado bioscience opportunities to out-of-state investors and venture funds; and making investments in private venture funds.

## Actions

### ACTION

#### 1

*Use tax credits to encourage private investment in early-stage capital and bioscience companies*

States are increasingly using tax incentives to encourage private investment in early-stage companies and/or funds that make early-stage investments. Nineteen states offer tax credits to angel investors who invest in technology companies, five of which are targeted specifically to angel investors who invest in bioscience companies. **It is recommended that Colorado enact legislation creating a tax credit for angel investors who invest in bioscience companies**, thereby reducing the risk for Colorado angel investors who made their wealth in other industry sectors and may feel uncomfortable investing in bioscience companies. Current angel investor tax credits vary greatly in the percentage of an investment that qualifies for the credit, ranging from 100 percent in Hawaii to 10 percent in New Jersey. The median among the 19 states that currently offer angel investor credits is 25 percent.

To ensure that the tax credit is used, efforts should be undertaken to educate and organize angel investors and introduce them to opportunities within the biosciences.

**It is also proposed that Colorado enact legislation creating a tax credit for investors in early-stage venture funds.** Ten states currently provide such tax credits. The Kentucky Investment Fund Act (KIFA) provides tax credits to individuals and companies that invest in approved venture capital funds. Investors in KIFA-approved funds are entitled to a 40 percent credit against Kentucky individual or corporate income tax or Kentucky corporate license tax.

### Maryland's Bioinvestor Tax Credit

Investors in Maryland can receive a 50 percent tax credit of the amount invested in a Maryland biotechnology company against corporate or personal income tax. Qualified Maryland venture capital companies can also qualify for the credit. Businesses and venture funds can receive a credit for investments of up to \$250,000; individuals can receive credits for investments up to \$25,000. A qualified biotechnology company must have: its headquarters and base of operations in Maryland, fewer than 50 FTEs, and been in business for no longer than 10 years. Any credit in excess of an investor's state tax liability may be refunded. The cap on total credits awarded is currently \$6 million; but, because demand has greatly outpaced this limit, the Governor has proposed raising this limit to \$12 million and then \$24 million over the next 2 years.

**Resources Required:** It is proposed that a \$5 million cap be placed on the tax credit for angel investors initially. This amount could be raised over time based on demand. A similar \$5 million annual cap on the early stage venture capital fund investment tax credit is proposed.

**Priority:** High

**Time Frame:** Short-term

ACTION  
**2**

*Explore options for creating a refundable or transferable R&D tax credit for bioscience firms and expand the existing biotechnology sales and use tax credit to medical device companies*

In addition to using tax policies to encourage investment in early-stage companies and both early- and late-stage investment funds, states use tax policy to ease the cash flow demands that bioscience companies

#### Connecticut's Refundable Tax Credits

Connecticut offers two refundable tax credits:

- A non-incremental credit of between 1 percent and 6 percent on qualified research expenditures, scaling upward with the level of expenditure, with a special 6 percent credit for qualified small businesses (defined as gross income less than \$100 million)
- A credit of 20 percent on the increment in qualified research expenditures over the base year per federal definitions.

For small businesses (defined as grossing less than \$70 million), the state will refund in cash 65 percent of the value of R&D credits that cannot be used because of lack of tax liability, in lieu of the carry forward option.

face as they seek to navigate the long process of bringing a new technology or product to market. Thirty-six states offer R&D tax credits. Unfortunately for many early-stage bioscience companies, a tax credit is not helpful because the firm is not yet profitable and therefore does not have any tax liability. To enable these firms to benefit from the credit, six states have made their R&D credit refundable, meaning that the business can exchange unused R&D tax credits with the state for a percentage of the value of the credit. Two states, New Jersey and Pennsylvania, allow the tax credit to be transferred to another firm.

Colorado offers a refund on state sales and use taxes paid by a biotechnology company on materials used for R&D. There is an R&D tax credit that is provided to taxpayers who make R&D expenditures, but only if they are located in an enterprise zone. **It is recommended that Colorado expand the existing biotechnology sales and use tax credit to medical device companies and enact legislation creating a refundable R&D tax credit specifically targeted to bioscience companies.** The credit could be fully refundable or refundable for a portion of the credit or, alternatively, the State could allow companies to sell the credit to another company. While some states make the issuing of such tax credits discretionary, it is proposed that firms that qualify receive the credit automatically since tax credits have more impact on a firm's behavior when they are provided of right rather than being considered discretionary.

**Resources Required:** The R&D tax credit could be funded with existing resources. It is estimated that expanding the biotechnology sales and use tax credit would require approximately \$2 million to \$2.5 million annually.

**Priority:** A refundable or transferable R&D tax credit is a medium priority. Expanding the existing biotechnology sales and use credit is a critical/high priority.

**Time Frame:** Short-term

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**ACTION**  
**3** *Continue and increase funding for the Bioscience and Life Science Fund (HB 08-1001) and allocate the additional funds for investments in bioscience companies*

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Colorado has taken an important step to support the commercialization of bioscience research discoveries by creating and funding the Bioscience and Life Science Fund. The Fund will provide grants to Colorado start-up companies and research institutions seeking to commercialize new biotechnology drugs, biofuels, medical devices, and nanotechnology. These grants can be used to support PoC projects, translational research, and start-up companies formed to commercialize university-developed technologies. The Fund will receive \$26.5 million in its initial 5 years. **It is proposed that the program continue to be funded beyond the initial 5-year time frame and that the size of the Fund be increased to \$7 million annually.** It is recommended that the additional \$1.5 million in funding be dedicated to providing capital for emerging Colorado bioscience companies, including companies not formed by Colorado research institutions that are not currently eligible for this funding. This increased funding will help to address the capital gap for seed funding in Colorado.

*Resources Required:* Total funding for the Bioscience and Life Science Fund will be \$7 million annually.

*Priority:* Critical

*Time Frame:* Mid-term

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**ACTION**  
**4** *Undertake activities to make out-of-state venture capital funds aware of investment opportunities in the Rocky Mountain region*

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Colorado and the Rocky Mountain region represent an emerging, fertile market for entrepreneurial activity and venture investment in the biosciences. Recent successes, such as Myogen (acquired by Gilead for \$2.6 billion) and Pharmion (purchased by Celgene for \$2.9 billion), suggest that Colorado is producing a pipeline of successful bioscience firms. An effort should be undertaken to increase the interest and involvement of national venture sources in Colorado bioscience companies. To accomplish this action will require not only having more locally managed funds that can partner with national funds, but also selling Colorado's successes to this market and organizing events, such as a bioscience investor conference, at which high-quality deals can be presented. As noted previously, Colorado ranks highly in terms of venture capital investment activity. The key will be to convince out-of-state venture funds that Colorado has significant opportunities in the bioscience arena.

*Resources Required:* Can be undertaken with existing resources.

*Priority:* High

*Time Frame:* Immediate

To increase the availability of risk capital, a number of states have invested in a “fund of funds” that in turn invests in privately managed venture funds that meet certain criteria, including a willingness to invest in the state. The fund of funds can also require that a certain percentage of the fund be invested in venture capital funds that target a particular technology area, such as the biosciences, or a particular stage of investment, such as seed and early stage. **It is proposed that Colorado create a \$250 million Fund of Funds that would invest in privately managed venture funds that are headquartered in Colorado or agree to make a good faith effort to invest in Colorado companies.** It is further proposed that a minimum of 30 percent of the total Fund dollars be invested in bioscience venture funds and that the focus be on funds that will address gaps in Colorado’s venture capital market, particularly at the seed and early-stage levels. Venture funds wishing to receive an investment from the Fund of Funds would be required to raise three times the Fund’s investment from other sources. Thus, the \$250 million invested in the Fund of Funds would raise \$750 million, a portion of which would be invested in Colorado companies. The amount that would be invested in Colorado companies would depend upon deal flow.

Potential investors in the Fund include the state pension funds (Public Employees Retirement Association), university foundations, other foundations, and other institutional investors. Alternatively, some states have created a fund of funds backed by contingent tax credits; to date, no state has had to use tax credits to reimburse investors. A good example of such a fund is the Utah Fund of Funds (refer to text box for details).

#### Indiana Future Fund

- \$73 million fund created in 2003
- Capitalized with investments by state pension fund, state teachers retirement fund, Eli Lilly, and Anthem Blue Cross/Blue Shield and endowments of four universities
- Required that:
  - 60 percent of investments to Indiana-focused or -based venture funds
  - 70 percent of funds that invest at early stage
  - 60 percent of investments in Indiana companies
  - 60 percent of investments in life sciences, targeted to specific technology platforms
- Invested in six local and national funds
- Managed for BioCrossroads by Credit Suisse ([www.indianafuturefund.org](http://www.indianafuturefund.org))

#### Utah Fund of Funds

Backed by \$300 million in refundable, transferable tax credits, the Utah Capital Investment Board (a state agency) guarantees institutional fixed-income investment (the first investment of \$100 million was taken by Deutsche Bank) in a pool of funds that is then managed by the Utah Capital Investment Corporation (a state-chartered nonprofit) under the advice of Fort Washington Capital Advisors of Cincinnati (selected in a competitive RFP process) and placed with venture funds with these characteristics:

- Possessing a successful track record or managers with successful track records
- Investing in companies in industries in which Utah consistently has high-quality investments available
- Showing or committing to show interest in making investments in Utah.

Fund I began operations in 2006 and had made 20 commitments as of February 2008, based on applications by more than 170 fund managers. Of the 20 funds selected, seven mention life science or health care explicitly as one or more of their targets. Just one of those seven also targets seed and early stage, although there are several other early/seed-stage funds in the “technology” (IT) or general multifield space. Of 359 investments reviewed as of February 2008, the selected funds had made 25 investments in Utah companies as of February 2008, investing \$127 million, leveraging \$365 million in other capital, and creating more than 1,000 jobs at an annual average salary of \$60,000. Perhaps most significantly to the state’s public-policy goals, partners at the investee venture funds had spent a cumulative total of 290 days in Utah, and Fort Washington itself opened a Utah office. ([www.utahfundoffunds.org](http://www.utahfundoffunds.org))

To begin planning for a Fund of Funds, it is proposed that the Governor convene a Capital Summit to bring together stakeholders and begin discussing capital needs and ways to address them in Colorado. The meeting could feature speakers from other states who have created similar programs who would share their experiences and lessons learned.

**Resources Required:** \$250 million from public and other institutional investors to be matched by \$750 million in private capital

**Priority:** High

**Time Frame:** Short-term

STRATEGY  
2

*Create a robust technology commercialization infrastructure in Colorado to rapidly move bioscience discoveries into the marketplace*

### Rationale

Despite the fast pace of bioscience research discoveries, a national crisis exists in the ability to translate innovative research discoveries into biomedical products. By itself, research will not translate into commercialization.

This gap between research discoveries and developing innovative new products is a well-recognized “valley of death” that suggests the need for a continuum of support, services, and assistance from the private and public sectors as a technology enterprise is conceived, developed, formed, and grown and reaches maturity (Figure 17). Tools needed to overcome the “valley of death” include conducting due diligence to determine the market potential, undertaking PoC applied research to demonstrate commercial viability, and supporting engineering optimization in developing the technology into prototypes that meet the demands of the marketplace.

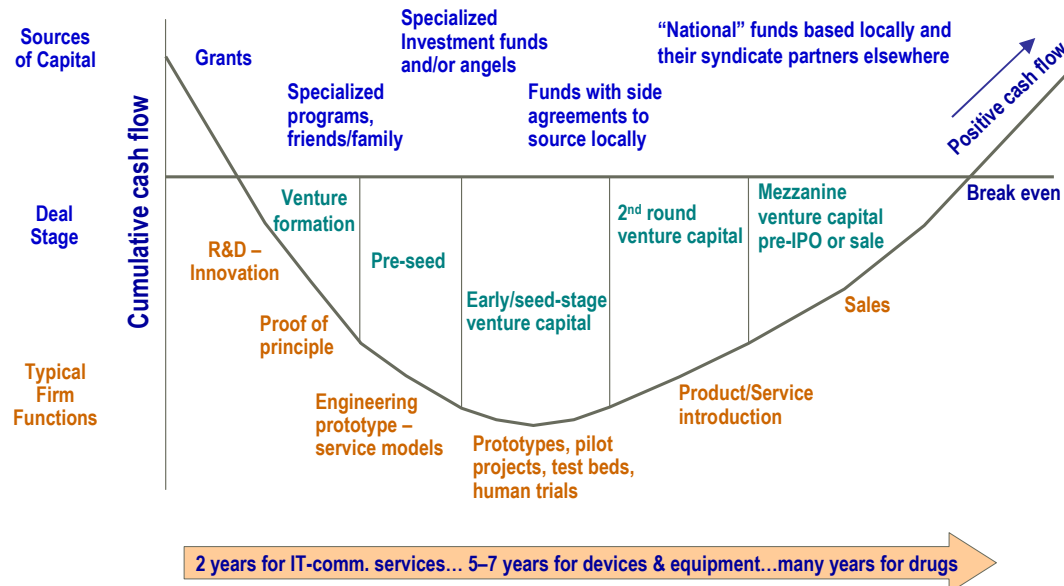
For the biosciences, the “valley of death” is a much longer and expensive process than for other technology areas, particularly IT. This longer, more costly process partly results from the highly regulated nature of bioscience innovation in which any new therapeutic and many medical devices must go through rigorous and expensive clinical trials.

Colorado has begun to put in place tools to advance technology commercialization by providing support for PoC activities. As more technologies advance through this stage, they will be better positioned to attract seed, early-stage, and later-stage venture capital. Colorado can help ensure that companies are able to obtain such capital by helping them develop effective business plans, access executive and management expertise, and access an infrastructure that supports preclinical development.

#### What is Technology Commercialization?

Technology commercialization brings together the technology derived from the research interest, risk capital to develop and engineer the product for manufacture and distribution, and entrepreneurial management talent to manage and steer the firm or product into and through the marketplace.

Figure 17: Research Discoveries – Valley of Death



## Actions

### ACTION

## 6

*Add bioscience capacity to local business development and entrepreneurial support networks*

The resources that bioscience entrepreneurs need include management talent, technology, linkage to sources of capital, professional expertise, and a host of other support services. They often need assistance in determining economic feasibility and identifying markets and distribution channels. They may also need access to specialized equipment and laboratories and to expertise to solve technical issues that arise during product development. They must be able to recruit essential personnel and have access to sources of concept, translational, pre-seed, seed, and other risk capital.

Colorado has a number of organizations and programs that provide such services to entrepreneurs, including FBBp, CSU Ventures, the BIC, the Fort Collins incubator, and the Longmont incubator. But, each organization has limited resources and operates primarily within the region in which it is located. These organizations work with

### Oklahoma Technology Commercialization Center

An example of an organization that provides comprehensive, in-depth support to entrepreneurs is i2E (Turning Innovation into Enterprise) in Oklahoma. i2E is a nonprofit organization that operates the Oklahoma Technology Commercialization Center (OTCC) and administers Oklahoma's Technology Business Finance (TBF) Program and the state's seed fund. The OTCC was created in 1998 to provide a focal point for entrepreneurs and technology-based companies. It was designed to be a single point of entry that could assess their needs, guide them through the commercialization process, and link them to a comprehensive network of commercialization assistance services. The Oklahoma Center for the Advancement of Science and Technology, the state's technology-based economic development agency, awarded the contract to operate the commercialization center on a competitive basis. i2E manages the commercialization center.

Through hands-on educational and training support and detailed consulting, i2E plays an important role in positioning Oklahoma entrepreneurs to grow viable businesses. It helps start-ups focus their business plans and strategies. i2E also helps entrepreneurs secure angel financing and other early-stage funding, including through the TBF, which can provide up to \$150,000 for PoC work. The company agrees to pay the money back at a rate of 2:1 after 5 years if it is successful in getting a product to market. The initial investment in TBF was \$5 million; approximately \$1.5 million has been repaid by successful clients.



entrepreneurs across a range of technologies, with only FBBp's focused exclusively on the biosciences. There are also gaps in the services that are available.

CBSA should bring expertise in bioscience business development to add capacity to these existing programs. CBSA should link bioscience entrepreneurs to resources that provide access to capital, facilities, and incubator space; assistance with IP issues; and marketing and business assistance. CBSA should work with the state's existing regionally based bioscience business development organizations to identify gaps in services for bioscience entrepreneurs and companies and determine how best to address them. For the various organizations to provide expanded support to bioscience companies, they will need additional resources that could be provided by state government or by regionally based organizations or their host institutions.

*Resources Required:* \$300, 000 to \$400,000 annually

*Priority:* Critical

*Time Frame:* Short-term

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ACTION  
**7**

*Establish a Bioscience Executive Corps to serve as mentors to start-up bioscience companies*

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Despite the fact that Colorado is starting to produce a number of entrepreneurs who have succeeded in starting and growing one or more bioscience companies, the state still lacks a critical mass of such people; start-up companies have difficulty in recruiting experienced CEOs, COOs, and other senior managers. One approach that is being used by several states and regions, including Pittsburgh and St. Louis, to address this need is a Bioscience CEO-in-Residence program.

The Pittsburgh Life Sciences Greenhouse has a Bioscience Executive-in-Residence Program that provides a pool of experienced senior managers available to start-up firms as interim executives to manage company formation and the pursuit of pre-seed and seed funding. They often work with university faculty and other researchers trying to launch a new enterprise. Once the firm has obtained its first round of venture capital, the CEO can either join the firm as full-time management or be replaced by an externally recruited CEO and return to the executive corps to work with additional companies. The program provides an opportunity for bioscience managers who want to locate in the region or who are between positions. Similarly, St. Louis has CEO-in-Residence positions located at its two bioscience incubators – the Center for Emerging Technologies, located close to Washington University and the city's biomedical complex, and the Nidus Center, which is a plant science incubator located close to the Donald Danforth Plant Science Center. The CEO in Residence mentors firms in the incubator and is expected to eventually take a position as CEO of an incubator company that is ready to graduate from the incubator.

Colorado has a growing number of successful bioscience entrepreneurs who are already working with start-up bioscience companies on an ad hoc basis. **It is recommended that CBSA play a more active role in identifying individuals with expertise in launching and running a bioscience firm willing to enter into a mentoring relationship with one or more start-up companies.** CBSA should work with the members of the business development and entrepreneurial support network to link bioscience mentors with the appropriate entrepreneurs or start-up companies.

The business development and entrepreneurial support network should examine the need for a more formal CEO-in-Residence program, along the lines of the Pittsburgh and St. Louis initiatives.

*Resources Required:* Can be implemented with funding provided to add bioscience capacity to the state's business development and entrepreneurial support network.

Priority: High

Time Frame: Short-term

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ACTION

8

*Create a Colorado Drug, Diagnostic, and Device Development Institute*

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Colorado has taken steps to improve university technology transfer and commercialization, and its research institutions are spinning off new companies. Colorado could become a leader in translating discoveries into new drugs, diagnostics, and biomedical devices if an infrastructure is put in place to accelerate this process.

**It is proposed that a new nonprofit organization, the Colorado Drug, Diagnostic, and Device Development Institute, be created with the mission of accelerating the commercialization of biomedical technologies.** The Institute would be a regional collaboration with a small, high-level scientific and executive team which would work with university technology transfer offices and bioscience entrepreneurs to identify commercially promising technologies and develop them to successfully pass the various stages of preclinical development.

The types of activities that could be undertaken by the Institute include the following:

- Identifying the most commercially promising technologies from Colorado research institutions and bioscience entrepreneurs, including assessing the commercial potential of projects seeking PoC funding from the state's new Bioscience and Life Science Fund (HB 08-1001).
- Helping to develop preclinical roadmaps that specify the experiments and analysis necessary to efficiently obtain Food and Drug Administration (FDA) clearance for first-in-human testing (Phase I trials or other regulatory approvals) while avoiding costly and time-consuming mistakes.
- Managing and performing the preclinical work outlined in the Roadmap. It is assumed that Colorado's research institutions will be key clinical service providers offering access to core analytical labs, animal facilities, prototype shops, and clinical trials organizations. The Institute will also establish relationships with private service providers, including out-of-state providers if needed to fill a gap in Colorado's infrastructure.
- Forming companies to commercialize technologies after successful completion of preclinical work.
- Providing financing for the preclinical development of companies.
- Identifying key management and resources needed to complete a business plan.

The ultimate objective of the Institute would be to create companies that are appropriately positioned for significant institutional (Series A) venture funding that will enable them to hire employees, execute the clinical development plan, seek partners, and enter into Phase I clinical trials.

#### **Oregon Translational Research and Drug Development Institute**

The State of Oregon, through its Signature Research Centers program, has created the Oregon Translational Research and Drug Development Institute (OTRADI). OTRADI provides a value-added component to companies and universities to further develop their IP by performing the following types of tasks:

- Chemical and biological screens
- Validated targets
- Lead optimization
- Toxicology assays
- Medicinal chemistry
- Assay optimization.

OTRADI's staff includes a chemist, a cell biologist, and two research associates.

Initially, the Institute may want to focus on two to three areas in which Colorado has the greatest research strengths, expanding to other areas over time. Potential areas of focus include cancer, infectious diseases, medical devices, and the other areas within Colorado's targeted bioscience technology platforms.

**Resources Required:** Study currently underway to develop business plan. It is estimated that the annual cost will be in the range of \$4 million to \$5 million.

**Priority:** High

**Time Frame:** Short-term

## STRATEGY

### 3

*Ensure that Colorado is attracting, retaining, and producing individuals with the skills needed to meet future bioscience workforce needs*

## Rationale

The demands for a highly trained, technical workforce in today's knowledge-based economy are extraordinary and mounting. This is particularly true in the biosciences. At its core, the bioscience industry is a knowledge-based sector dependent upon the skills of its workers. Workers are needed to conduct research, translate innovation into product development and improved health care techniques, and ultimately to manufacture biomedical and other bioscience-related products. Thus, ensuring the availability of an educated, skilled workforce is critical to developing and sustaining a highly competitive, robust bioscience cluster over the long term. Colorado must continue to advance a pipeline of bioscience talent to support the future growth of this sector.

## Actions

### ACTION

### 9

*Create and fund a high school science teacher externship program*

To make students aware of careers in the biosciences and to prepare students to pursue bioscience degrees, the teachers must themselves be knowledgeable about the biosciences. One way of doing this is to place teachers at bioscience companies and research institutions to provide them with practical hands-on experience in the biosciences. CBSA initiated a pilot Teacher Externship Program that placed a high school biology teacher in a Colorado bioscience company to serve a 6-week externship in 2008. An externship, similar to an internship but usually of shorter duration, provides an opportunity to engage in practice-based learning by actively participating on the job in a bioscience company. The initial pilot program was funded with CBSA revenue raised from its annual Golf Tournament.

**It is proposed that this program be expanded and funded at a level sufficient to eventually enable 50 to 75 teachers to participate each summer.**

The teachers would receive both a stipend and continuing education credit. The proposed budget for the program includes the costs of the stipends, continuing education credits, and conducting all activities necessary to recruit and match

both companies and teachers. In addition, the program would have a strong research and evaluation component that would involve tracking performance over time. The program would continue to be operated

### **Arizona Biodesign Institute High School Internship Program**

In Arizona, 24 high schools with existing biotechnology programs were invited to send a teacher to participate in an internship during the summer of 2008 at Arizona State University's Biodesign Institute, a multidisciplinary biosystems research center. The teachers help select students to serve as interns as well. Each student/teacher team works on a research problem under the guidance of a Biodesign researcher. The daily exposure to large research teams and world-class facilities of the Institute give interns an in-depth introduction to the career of a bioscience research scientist. Fifty-eight students and teachers participated in the program in 2008. This level of participation was made possible by a \$50,000 contribution made by a local foundation.

by CBSA, which would recruit companies to participate in the program and match interested teachers with bioscience companies. Over time, the program could be expanded to involve students and to place both students and teachers in both research institutions and companies.

*Resources Required:* Total cost for this initiative is estimated to be \$600,000 annually.

*Priority:* High

*Time Frame:* Immediate

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ACTION  
**10**

*Establish a Bioscience Industry Fellows Program to place graduate and postdoctoral students in emerging bioscience companies*

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The talent pipeline in Colorado, as elsewhere around the country, lacks scientists with industrial experience. Colorado graduates a significant number of people with bioscience graduate and postgraduate degrees; but, there is no clear pathway to transition from academia to industry. Most small bioscience companies, the type of firms that typically compose Colorado's bioscience cluster, can afford to hire researchers only as technicians or senior scientists. Recent Ph.D. scientists are considered overqualified for technician positions and unqualified for senior positions. Mid-level scientific positions typically require both postdoctoral training and industry experience; yet, few companies provide transitional opportunities. One way to provide industry experience for graduates and postdocs and support for small companies that have very limited resources is by providing support for bioscience industry fellowships.

**It is proposed that Colorado significantly underwrite a Bioscience Industry Fellows Program that would support the placement of graduates and post doctoral students in bioscience companies.** Participating companies would be required to provide a senior scientist to mentor the Fellow. The program could begin initially by funding one to two Fellows annually. The number of Fellows could be increased as the program demonstrates success in future years.

The New Jersey Commission on Science and Technology offers a \$55,000 Technology Fellowship that allows postdoctoral students in all fields, including the biosciences, to spend time with early-stage companies. Fourteen company/postdoc pairs were selected for funding in 2005.

*Resources Required:* \$375,000 annually to support five fellows

*Priority:* High

*Time Frame:* Short-term

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ACTION  
**11**

*Continue to expand efforts to provide business and entrepreneurial education to bioscience students and to increase educational offerings to address critical skill needs.*

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Across the country, higher-education institutions are working to supply bioscience students with business development and entrepreneurial skills to enable them to work for start-up or emerging bioscience companies or pursue their own entrepreneurial endeavor after completing their degree. San Jose State offers a master of biotechnology program that integrates advanced, hands-on training in laboratory-based core biotechnologies from the Department of Biological Sciences with business courses in management/marketing at the Master of Business Administration (MBA) level from the College of Business. The University of Central Florida offers a master's degree in biotechnology with an MBA option. Indiana University's Kelley School of Business offers a Business for Life Science Executives program. The University of Kansas and

Washington State University both offer animal health MBAs. The Keck Graduate Institute of Applied Life Sciences, a member of the Claremont Colleges Consortium, was created specifically to educate scientists and engineers to be bioscience business leaders.

CU-Denver's Bard Center is developing a focus on bioscience entrepreneurship as a result of the merger of CU-Denver and CU's Health Sciences Center. The state's universities should be encouraged to expand such efforts and to consider ways to further integrate business and bioscience curricula. At the same time, the state's higher-education institutions should work with the state's bioscience industry sector to identify skill needs and to develop programs and initiatives that address them.

Activity is already underway in Colorado to offer new bioscience degrees. CSU is developing a master's degree in Biocontainment and working with Front Range Community College on an animal technician program. A new School of Public Health has been created, which is a consortium of CU-Denver and the Health Sciences Center, CSU, and the University of Northern Colorado. Regulatory affairs and clinical trials, two areas of skill shortage identified by Colorado's bioscience industry, reflect a nationwide shortage of talent; and programs are being developed in response to this need. The University of Georgia's College of Pharmacy, for example, established a clinical trials design and management certificate program and a pharmaceutical and biomedical regulatory affairs graduate certificate program. Colorado could explore the possibility of offering certificate or degree programs in clinical trials and regulatory affairs or other areas identified by the state's bioscience companies.

*Resources Required:* TBD

*Priority:* Medium

*Time Frame:* Mid-term

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ACTION  
**12**

*Create a nonprofit CBSA Foundation to develop and support bioscience programs to ensure that Colorado has the talent to meet the future workforce needs of the state's bioscience sector*

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While some actions have addressed bioscience workforce needs in Colorado today, continuing dialogue will be needed regarding workforce needs and programs. Initiatives must be developed to address the ever-changing skill mix that will be needed as the industry continues to evolve and as Colorado's bioscience sector matures. **It is proposed that CBSA create a nonprofit foundation to serve as a bridge between educational institutions and bioscience companies and to build comprehensive education initiatives that advance bioscience scientific literacy.** This foundation would perform the following:

- Facilitate communications between the state's bioscience companies and the education and workforce development system.
- Continue efforts to expose high school teachers to the biosciences through summer institutes and externships, with a particular emphasis on teachers in rural areas.
- Institute a bioscience internship program to work with firms to understand the positions for which interns are needed and to reach out to identify students who have the skills to fill particular internship positions.
- Work with the state's educational institutions to develop specialized bioscience high school programs.
- Conduct outreach activities to expose students and parents, particularly in rural Colorado, to bioscience career opportunities and their prerequisites.
- Administer the Bioscience Industry Fellows Program.

*Resources Required:* Initial planning for the Foundation can be conducted using existing CBSA resources. Programmatic funding needs will be developed as plans for the Foundation progress.

*Priority:* Critical

*Time Frame:* Short-term

STRATEGY

4

*Promote Colorado's position as a leading bioscience center*

### Rationale

Colorado has an emerging bioscience cluster and very strong bioscience research assets, but neither Colorado nor its metro areas are generally recognized as leading bioscience centers. Progress has been made within the state in raising the visibility of the bioscience sector as a key driver of the state's technology economy in the last 5 years, and the state's business development efforts include a focus on the bioscience industry. During the next 5 years, Colorado will need to promote its bioscience assets both nationally and globally. It will be important to differentiate Colorado from the various states and regions across the United States that also are seeking to grow their bioscience economies. Colorado can do this by developing and implementing a branding and marketing strategy that focuses on the state's bioscience technology platforms and continuing to implement a bioscience business development effort.

### Actions

ACTION

13

*Ensure that the Governor's Office of Economic Development and International Trade continues to maintain dedicated bioscience staff*

Staff who possess in-depth knowledge and understanding of the bioscience industry and are able to link together and package state financial, regulatory, and other programs to assist bioscience companies are absolutely essential to any state bioscience development effort. The bioscience industry sector is one specifically targeted for development in Colorado. The OEDIT markets Colorado's bioscience assets and assists bioscience companies wishing to locate in Colorado. **It is recommended that OEDIT continue to designate staff to be responsible for coordinating bioscience initiatives, assisting existing bioscience companies, working with bioscience companies that are considering locating in the state, and acting as liaison between government and the industry.** The presence of a designated bioscience industry specialist further indicates the state's commitment to the bioscience industry.

*Resources Required:* This action can be accomplished with existing resources.

*Priority:* Critical

*Time Frame:* Immediate

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ACTION  
**14**

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*Develop and implement a bioscience branding and marketing strategy and communications campaign*

Many regions of the country are trying to reposition themselves as bioscience centers, with varying degrees of success. One approach to marketing a state or region in the biosciences is to establish a brand name. Two communities that have successfully branded themselves in the biosciences are St. Louis with its BioBelt and Minnesota with Medical Alley. Colorado needs to develop a bioscience image/brand that

- Reflects realistic opportunities for Colorado in bioscience development but also conveys the state's bioscience vision for the future
- Distinguishes Colorado from its competitors
- Portrays Colorado's strengths, not only in the biosciences, but in regard to quality of life
- Reflects a consensus of the entire bioscience community
- Is memorable and easy to communicate.

Colorado needs to demonstrate and communicate that companies and institutions coming to or growing in the state will find a supportive environment in which they can thrive by finding the talent, research and commercial relationships, and access to capital and specialized facilities that are critical to growing a successful bioscience company.

**It is proposed that CBSA, in partnership with OEDIT, the Metro Denver EDC, and other economic development organizations, bring key bioscience stakeholders together to ensure that the marketing and branding strategy is developed with strong support of the bioscience community.** This group would engage an experienced marketing/public relations firm to develop and execute a bioscience marketing strategy.

An internal communications campaign also should be initiated to increase Colorado's policymakers', legislators', and residents' knowledge and understanding of the biosciences; the role they play in Colorado'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, research, and bioscience industry development can have on their constituents. The internal education 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 and a bioscience ambassador program to reach schools and local civic organizations.

#### **Research Triangle and St. Louis Branding**

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Best practices in bioscience marketing call for an "alliance" approach coupled with strong internal marketing. An active alliance marketing program brings together state, county, and local economic development organizations; universities; local bioscience industry organizations; and companies to recruit outside investments and new business expansion. Alliance-related activities include active presence at trade shows, overseas and other trade missions, and even developing sister-state/sister-city relationships.

Two areas that have been very successful in using these approaches are Research Triangle and St. Louis. In North Carolina, the North Carolina Biotechnology Center helped to identify and recruit life science companies with fly-ins of executives and tours with strong industry and university involvement. St. Louis has formed a Coalition for Plant and Life Sciences in close partnership with the St. Louis Regional Chamber and Growth Association (RCGA) that enables highly coordinated outreach marketing involving universities, incubators, professional organizations, and others.

But, what makes an alliance marketing approach possible is an active focus on internal marketing to build the needed community support and enable all key segments of the community to be involved in the outreach effort. Internal marketing for North Carolina included outreach to local schools in promoting life science careers and active news stories on life science industry developments. St. Louis has had great success in its internal marketing through the use of networking as well utilizing the RCGA's Technology Gateway Life Sciences Network.

**Resources Required:** It is estimated that \$500,000 will be needed to develop and implement the branding and marketing strategy and communications campaign. These funds should be provided by the various economic development partners using either redirected or new dollars.

**Priority:** High

**Time Frame:** Short-term

STRATEGY  
5

*Ensure Colorado's bioscience future by making a long-term commitment to support the development of the bioscience sector*

### Rationale

To be a global leader in the biosciences, the State of Colorado must demonstrate its commitment to the biosciences by recognizing the sector's contribution to the state's economy and fully supporting the significant investments that will be required over the long term in the state's bioscience research and commercialization infrastructure. Taking note of the investments of competitor states aids understanding of the magnitude of the investments being made in the biosciences. Massachusetts enacted a 10-year, \$1 billion Life Sciences Initiative in 2008. This umbrella program includes \$500 million in capital funding, \$250 million in granting authority, and \$250 million in tax credits. The initiative will provide funding for major university R&D facilities, make miscellaneous improvements in biomanufacturing and wet-lab incubation, extend the state's operating loss carryforward to 15 years, ease provisions of the state's R&D tax credit, and provide sales tax exemptions for bioscience R&D and manufacturing facilities. The Governor of Maryland has proposed a similar 10-year, \$1.1 billion bioscience initiative that will be considered by the Legislature in 2009. Such state investments pale in comparison to the level of investment in places like Singapore that has strategically aligned itself to be cutting edge in its bioscience and clinical research, manufacturing, and health care. If Colorado wishes to compete in the biosciences, it must continue to invest in its bioscience research, commercialization, and health care infrastructure at the same time continuing to address the needs of its bioscience companies.

**States are investing significant resources to develop their bioscience infrastructures**

- Massachusetts Life Sciences Initiative – \$1 billion
- Missouri Lewis and Clark Discovery Fund – \$335 million
- Texas Emerging Technology Fund – \$100 million annually
- Washington State Life Sciences Discovery Fund – \$350 million

ACTION  
15

*Continue to support ongoing bioscience development projects and fund new ones as needed, including Anschutz Medical Campus, Colorado Science + Technology Park at Fitzsimons, CIMB, CSU Superclusters, and Colorado Renewable Energy Collaboratory*

As noted in the section on key accomplishments, state government and Colorado's research institutions are making significant investments in facilities and infrastructure to support the bioscience research enterprise. Full build-out of the former Fitzsimons Army Medical Center is estimated to cost \$5 billion. Additional multitenant lab and office buildings are planned at the Colorado Science + Technology Park at Fitzsimons.



Recent and proposed investments to support academic bioscience facilities and initiatives total more than \$800 million and include the following:

- CIMB, \$200 million
- Systems Bio Building at CU-Boulder, \$113 million
- UC Denver Biomedical Initiatives, \$275 million
- CSU's Rocky Mountain Regional Biocontainment Lab, \$30 million
- CSU's Centers for Disease Control and Prevention Division of Vector-Borne Infectious Diseases Lab, \$80 million
- CSU's Research Innovation Center, a \$50 million joint university/federal research lab complex
- Proposed new Science and Engineering Building at UCCS, \$53 million
- University of Denver nanotechnology facility, \$10 million.

Some of these projects are funded while others will still need to raise funds. Investment in such facilities and programs will be needed to ensure that Colorado's universities and medical centers have the researchers, laboratories, and equipment to compete successfully for bioscience R&D dollars and to continue to produce talented bioscience graduates.

*Resources Required:* Determined on a project-by-project basis.

*Priority:* Critical

*Time Frame:* Ongoing

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ACTION  
**16**

*Identify revenue sources and create a fund to support bioscience policies, programs, and infrastructure investments in the long term*

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If Colorado is serious about being a global leader in the biosciences, the state's public and private sectors will have to commit to investing in the types of initiatives called for in this Roadmap over the long term, just as many of its competitor states have done. Many of the actions proposed here will require annual expenditures; others will require one-time expenditures. **It is recommended that the Colorado bioscience community develop a proposal for a large, multipurpose fund that could strategically invest in bioscience infrastructure – including facilities, faculty, equipment, and capital – thereby able to allocate funding to the greatest demand at any given time.** The Colorado Bioscience Fund would be used to support the following:

- Collaborative research, including translational, scale-up, and demonstration programs – focused on technology platform development
- Endowed Chairs – focused on technology platform development
- Signature Research Centers – focused on technology platform development
- Facility development
- Continued development of the Anschutz Medical Campus and the Colorado Science + Technology Park at Fitzsimons
- Matching funds to attract major research anchors

- Development of incubators and research parks
- Commercialization support.

Various sources could be tapped to support the Fund, including the creation of a dedicated tax. This approach was taken in Arizona. In 2000, Arizona voters approved Proposition 301, which increased the state's sales tax by 0.6 percentage point, generating funding for education, with 20 percent of the total set aside for a Technology Research and Initiative Fund (TRIF). TRIF funding has been used for bioscience infrastructure projects. Kansas is funding the Kansas Bioscience Authority (KBA) with incremental personal income-tax collections in designated bioscience industry sectors. KBA is using the revenue stream to fund university-industry research centers and Eminent Scholars, to provide match for major federal or industry awards, and to support a variety of other activities.

Many states, including the Massachusetts Life Sciences Initiative discussed above, use state appropriations to support the development of the state's bioscience infrastructure. Voters in Maine approved \$50 million in bond funding to create the Maine Technology Asset Fund, a 2-year competitive award program for investment in R&D and commercialization, including within the biosciences. Lastly, some states and regions have been successful in leveraging philanthropic foundation resources to support investment in the biosciences. One or a combination of these revenue sources could be tapped to fund the Colorado Bioscience Fund.

**Resources Required:** Based on the experience of other states, it is expected that Colorado will need to invest several hundred million dollars during the next 5 years to remain competitive in the biosciences. The exact level of resources that will be needed will be determined as the fund is designed.

**Priority:** Critical

**Time Frame:** Short-term

## Summary

The strategies and actions outlined in this Roadmap provide direction for the public and private sectors as Colorado continues to support the development and growth of its bioscience sector. It is envisioned that these actions will be taken during the next 5 years, with some being implemented sooner and others requiring more planning and development. The next chapter of this Roadmap proposes an implementation plan that identifies steps that should be taken within the next year and performance measures that should be tracked to ensure that implementation is proceeding and that Colorado is making progress in achieving its bioscience vision.

# IMPLEMENTATION PLAN

Various members of the bioscience community cooperated in 2003 in developing an action plan to grow Colorado's bioscience industry cluster. The bioscience community came together again in 2008 under the leadership of CBSA to assess progress and develop a roadmap to guide Colorado's bioscience development effort for the next 5 years. Much has been accomplished since 2003; but, there are still gaps to be addressed and opportunities to be realized before Colorado will achieve its vision of being the life science center for the Rocky Mountain region and home to a robust cluster of bioscience and technology companies that are developing innovative products to address health care, environmental, clean energy, agricultural, veterinary, and national security needs.

This implementation plan identifies immediate work plan priorities, outlines important success factors, and proposes measures of success.

## Immediate Work Plan Priorities

Immediate work plan priorities are those steps the private and public sectors should undertake in the first 12 months of implementation. Several critical priorities need to be addressed right away, while others will need to be planned and resources secured before they can move forward.

The following ten actions should be undertaken in the first year of strategy implementation:

- 1 **Hold a Governor's Capital Summit to begin planning for a Fund of Funds.** *A first step in developing a proposal for a Fund of Funds would be to bring together all of the stakeholders. The program could feature managers of funds from other states to describe their funds and discuss lessons learned. CBSA and OEDIT should partner to plan and hold the Summit.*
- 2 **Implement a statewide business development and entrepreneurial support network through CBSA.** *Colorado already has a number of organizations that provide assistance to entrepreneurs and start-up companies seeking to commercialize bioscience discoveries. To begin creating a statewide network, CBSA should convene the various service providers to identify their services and requirements and to identify any gaps in services. A working group should be formed to develop a framework for the functions of the network.*
- 3 **Identify experienced bioscience executives willing to mentor bioscience entrepreneurs and emerging bioscience firms.** *CBSA should initiate an effort to identify bioscience executives willing to mentor entrepreneurs and emerging companies and work through the partners in the business development and entrepreneurial support network to link entrepreneurs and mentors.*
- 4 **Create CBSA Foundation to focus on talent issues.** *Moving forward with this action will require obtaining CBSA Board approval, developing a mission and defining the role of the foundation, deciding on an organizational structure, and obtaining initial funding support.*

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- 5 **Propose legislation creating tax credits for angel investors and investors in early-stage venture funds.** CBSA, working in partnership with OEDIT, should draft legislation that can be modeled on the legislation in states that have such tax credits.
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- 6 **Propose legislation to expand the biotechnology sales and use tax credit to medical device companies.**
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- 7 **Propose legislation to create and fund a science teacher externship model program.** CBSA and the state's department of education should develop a proposal for a program to submit to the Legislature for funding.
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- 8 **Initiate Rocky Mountain Investor Conference in 2009 and explore opportunities for regional cooperation to promote the Rocky Mountain Region Bioscience Cluster.**
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- 9 **Begin discussions and initial planning for the Colorado Bioscience Fund.**
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- 10 **Develop a business plan for the Colorado Drug, Diagnostic, and Device Development Institute**
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## Important Success Factors

Success in achieving the bioscience future envisioned in this Roadmap will depend on the following:

- The **commitment of key stakeholders** – the research community, the business community, the medical community, and state and local government – to implementing the Roadmap and providing the financial support required. Colorado committed boldly to developing the Anschutz Medical Campus and the Science + Technology Park at Fitzsimons. A commitment of this scale will be needed to allow Colorado to move past its competitors and become a leading bioscience center.
- **Willingness of institutions, organizations, and regions to partner and work collaboratively** to achieve a common vision of Colorado's bioscience future. Each of Colorado's research institutions has developed strengths in crucial bioscience areas; but, the areas that offer the most opportunity for development are those in which the various institutions can work collaboratively, using complementary strengths to address key bioscience needs.
- **Continued support from the State of Colorado.** During the past 3 years, the Governor and the Legislature have enacted new initiatives aimed at supporting the bioscience industry sector. Many of the actions in this Roadmap will require either legislative action or state resources. To fully implement this Roadmap, state government must continue to support such initiatives.
- **Leadership of the state's bioscience industry executives.** CBSA, working with member companies and its partner organizations – the OEDIT; Metro Denver EDC; CU; CSU; and regional representatives from Aurora, Denver, Fort Collins, and Colorado Springs – has facilitated the development of this Roadmap. It will be important for the CBSA to take the lead in overseeing implementation of the Roadmap and, through its membership, develop a next-generation strategy for

CBSA. Just as Colorado's bioscience sector is maturing, so must the organization that represents the industry change to meet emerging member needs.

## Measures of Success

If the investments proposed in this Roadmap are made, Colorado should achieve the following performance goals during the next 5 years:

- Raise a \$250 million Fund of Funds.
- Achieve \$300 million annual venture capital investment in Colorado bioscience companies, with 10 percent of the increase in early- and seed-stage investments.
- Build up number of Colorado bioscience firms completing preclinical development, as measured by the number of companies that file investigational new drug (IND) applications with the NIH and investigational device exemptions (IDE) with the FDA on an annual basis.
- Increase the state's bioscience economic base as measured by number of firms, their employment, and their concentration in the state relative to the nation. Maintain the state's specialization in medical devices (1.25 LQ) and achieve a statewide specialization (1.2 LQ) in research, testing, and medical laboratories by 2012.
- Maintain or increase the specialization of the biosciences in Colorado's metropolitan areas: Boulder (maintain or increase 3.57 LQ), Colorado Springs (target to reach 1.0 LQ), Denver/Aurora, (target to reach 1.0 LQ), and Fort Collins (target to exceed 1.2 LQ).
- Create at least one major new bioscience degree program at the undergraduate or graduate level and create at least three new certificate degree programs for related professions.
- Achieve or exceed the national growth in NIH funding in Colorado.

CBSA, working in partnership with Colorado's academic institutions, economic development organizations, and state government, should take responsibility for collecting the performance data and assessing progress in implementing the Bioscience Roadmap. An annual progress report should be prepared and widely disseminated among stakeholders, the bioscience community, and the citizenry.



# CONCLUSION

In 2003, the Action Plan team found that Colorado had a substantial foundation on which to build a bioscience industry cluster. In 2008, the Battelle team finds that significant progress has been made on many fronts in terms of building that cluster. Colorado is home to both established and emerging bioscience companies, with a very strong and specialized medical device subsector and a rapidly growing research, testing, and medical laboratories subsector. Colorado's metropolitan areas are home to strong clusters of bioscience activity, each with its own distinct niche. Colorado has continued to build its research strengths and has the potential for becoming truly world-class, working across institutions to advance its bioenergy, electronic medical device, and pharmaceutical biotechnology platforms.

But, gaps in Colorado's bioscience support infrastructure still need to be addressed if Colorado's bioscience sector is to become a national and global leader. Colorado could become a leader in translational medicine; but, to do so will require significant investments on the part of public and private sectors and a commitment to continue to develop a climate supportive of the biosciences. Colorado must ensure that companies are able to obtain risk capital; develop a seamless bioscience technology commercialization network; attract, retain, and develop bioscience talent; and invest in the state's bioscience research infrastructure in order to make the biosciences a driver of Colorado's future economy.

This Roadmap proposes a set of strategies and actions to address these issues and achieve Colorado's bioscience vision. It will be a challenge for Colorado to achieve the goals set out in this Roadmap; but, doing so will result in not only high-wage, high-skilled jobs but also better health care, improved environmental quality, and a better quality of life for Coloradoans.

