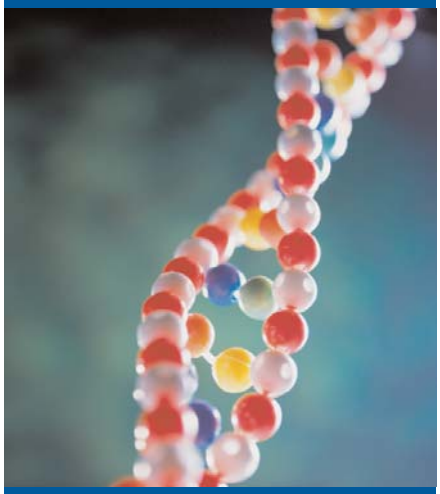
EXECUTIVE SUMMARY







PLATFORM FOR PROGRESS:

ARIZONA'S BIOSCIENCE ROADMAP

PREPARED FOR:
Flinn Foundation

PREPARED BY:
Technology Partnership Practice
Battelle Memorial Institute
Cleveland, Ohio

December 2002

Battelle
The Business *of* Innovation

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INTRODUCTION

Now is an opportune time for Arizona to initiate bold action to ensure long-term prosperity for its citizens through a comprehensive partnership of its private and public sector leadership to build Arizona's future in selective fields of the biosciences. In recent months, much public attention and momentum has resulted from Arizona's successful efforts to attract the Translational Genomics Research Institute (TGen) and the International Genomics Consortium (IGC). However, TGen and IGC are but one anchor of a much broader set of strategies and actions that will be necessary to position Arizona as a major southwest bioscience center over the coming decades. To address this issue, Arizona's leaders are seeking to develop strengths in those technology areas expected to lead future economic growth—chief among them is the bioscience sector.

This Roadmap Alliance lays out a comprehensive approach to accomplish this plan, with details in the full report and highlights in this executive summary. This Roadmap proposes a bioscience agenda based on private sector market-driven needs, and recommends actions that are implemented around filling private sector gaps through private-public partnerships, led by industry.

Arizona must play "catch up" to other states in building a world-class research base, as well as translating this base into clinical care, treatment, and commercialization of technology through building a critical mass of bioscience-related firms. This Roadmap identifies three near-term technology platforms in which the state's research universities and related medical and other research organizations have existing and emerging strengths on which to build—neurological sciences, cancer therapeutics, and bioengineering. Focusing on key platforms—rather than trying to spread limited resources across multiple areas—may be the best approach for Arizona to catch up and excel in key research areas, the absolute prerequisite to improved quality health care delivery and creation of well-paying jobs.

Arizona has reached a critical first phase in building momentum in the biosciences. Translational research linking bench to bed and classroom can "fast track" Arizona on this path to bioscience stature. Technology commercialization must be concurrently addressed if the state is to build a critical mass of bioscience firms and to apply research to patient care and quality health care delivery. Arizona's current situation is not unique. Other states and regions once behind in the development of their bioscience sectors (including San Diego, California; Montgomery County, Maryland; Birmingham, Alabama; and Portland, Oregon) have either successfully positioned themselves as a leading bioscience region or are focusing their strategic investments to carve out a particular market niche for the future.

ARIZONA'S BIOSCIENCE VISION

With strong public and private leadership and long-term commitment, Arizona can achieve the following vision in the next 10 years:

> ***Arizona is a leading southwestern state in selective bioscience sectors, built around world-class research, clinical excellence, and a growing base of cutting-edge enterprises and supporting firms and organizations.***

MISSION

To achieve this vision, Arizona must approach its future in the biosciences by

- **Further investing in and building Arizona's world-class research and clinical and product excellence around selective bioscience sectors. The goal is to have Arizona's growth rate in National Institutes of Health (NIH) research funding comparable to that of the top 10 states in the nation by 2007.**
- **Putting in place mechanisms, programs, and incentives that encourage research to be turned into products, processes, and wealth generation for the state and its citizens. Vehicles must be in place to accelerate the ability to "mine" a growing research and development base for commercial and technological development.**
- **Mobilizing public and private leadership and increasing citizen knowledge and understanding of the biosciences and its impact on health and safety, teaching and research, and economic development (bench, bed, and classroom).**
- **Building "trees of talent" by encouraging scientific and technical talent to be developed and retained in the state.**

Arizona has the potential to develop its leadership in key focused bioscience technology platforms, but developing the biosciences in Arizona will require

- ***Patience and a long-term commitment***. One lesson from every successful technology community is that success takes time. Developing a bioscience sector cannot be accomplished in a year or two. It requires a long-term effort, measured in a decade or more.
- ***Champions.*** To be successful, the development of the biosciences in Arizona must have champions—leaders with the ability to bring all of the relevant players to the table and the means to see that the strategic recommendations are implemented.
- ***Strategic focus.*** Successful states and regions have recognized that they have neither the capacity nor the assets to excel in all areas of technology. Instead, they have examined their comparative advantages, within both their industrial and research bases, and focused their investments on competitive niches in which they can and do excel.
- ***Strong public-private partnerships.*** Growing a state's bioscience sector requires collaboration and strong working partnerships between and among the state's higher education, industry, nonprofit, and philanthropic leaders. Those leading states and regions in the biosciences and other technology fields have established highly linked and interactive

processes in which research excellence and a growing industry base are pursued simultaneously in a highly connected manner, supported with private, foundation and public investments.

- ***Active state and local government support.*** The federal government is widely recognized as the principal driver of basic research in the United States. Therefore, what is the role of state and local government? The state and local role is to ensure that the required infrastructure, such as research facilities, faculty, and physical infrastructure, is in place to leverage federal dollars. Their economic development role is to help find solutions to fill market gaps in ways that support, spur, link, and leverage ongoing private investments. These economic development efforts include focusing on public supported research universities; addressing the future talent pool through education and workforce programs; and ensuring a high quality of life, including a sound tax and regulatory climate. A related but important role of state government is improving the quality and access to health care within its borders, including research that translates into health care practice and treatment.
- ***Willingness on the part of the state's research institutions to partner.*** In today's competitive bioscience field, no one research entity will be able to "go it alone" effectively. For real success to occur, research institutions will need to partner to leverage resources, funding, and scarce knowledge assets.

WHY BIOSCIENCES IN ARIZONA?

Arizona has experienced tremendous population and economic growth during the past decade. Between 1995 and 2001, the state's population grew by 23 percent. Arizona's economy has grown just as rapidly, and the state has made progress in attracting and retaining technology jobs in the electronics and aerospace sectors. However, Arizona has not yet developed a diversified knowledge-based economy. Arizona ranks below average, for example, in terms of the number of residents working in knowledge-intensive sectors of the economy.[1]

Reasons for focusing on the development of the biosciences in Arizona include the following:

- *The bioscience sector is one of the fastest growing and most dynamic sectors of the economy*. Advances in the biosciences are likely to be a primary driver of future economic growth, when combined with their convergence with information technologies.
- *Bioscience research will lead to advances that will improve the health and quality of life of Arizona residents*.
- By virtue of its size and diversity, *the bioscience sector offers the opportunity to create new firms, high-wage jobs, and income, thereby creating wealth for Arizona citizens.*
- *The bioscience sector can build on Arizona's existing manufacturing and information technology strengths in fields such as electronics and optics.*
- *The bioscience sector can bring stability to Arizona's economy*, necessary to balance more cyclical industries such as travel and tourism.

[1] Morrison Institute for Public Policy. *Arizona Policy Choices 2001: Five Shoes Waiting to Drop on Arizona's Future*, October 2002, p. 28.

- *The bioscience sector offers employment opportunities across a broad range of occupations, thereby providing jobs for Arizona residents at various skill levels.*

In summary, Arizona's elderly and growing minority population bases will demand quality health care, which itself will benefit from the fruits of medical research and the availability of talented health workers – from technicians to postdoctoral fellows. Growth in the medical device, agriculture, and other biotechnology sectors offers job opportunities for these graduates so they may remain in Arizona and become employed in well paying jobs.

METHODOLOGY

But, can Arizona succeed in growing its bioscience sector and, if so, what will it require? In 2002, the Flinn Foundation engaged Battelle Memorial Institute's Technology Partnership Practice (TPP) to assist the Foundation and its partners, which include the Arizona Department of Commerce, the state's universities and medical institutions, local development organizations, and the business community, in developing a Bioscience Roadmap to grow the biosciences in Arizona. Battelle is one of the world's largest nonprofit research and development organizations. TPP assists public and private sector organizations seeking to grow their economies through technology-based economic development.

What will it take to grow the biosciences in Arizona? To answer this question, the Battelle team

- Conducted an **economic analysis** of Arizona's existing bioscience industry, identifying trends, current strengths, emerging industries, and emerging clusters within the bioscience complex.
- Prepared a **benchmarking analysis** that compares Arizona with other states that either are or are striving to become leading bioscience centers.
- Assessed Arizona's position in bioscience research and identified technology areas for future development through a **core competency review.**
- Identified **barriers to and gaps** in private and public investments, policies, programs, and activities that might hinder Arizona's ability to become a leading state in the biosciences.
- Developed this Roadmap that lays out a **vision** for the biosciences in Arizona and identifies the **strategies and actions** necessary to achieve this vision.

ARIZONA'S BIOSCIENCE INDUSTRY BASE

Arizona possesses an economic base in the biosciences that is small but rapidly expanding, outpacing national growth trends.

Arizona's bioscience employment base[2] has grown nearly 80 percent over the past six years, now consisting of approximately 450 establishments employing 9,100 workers. As a result, Arizona's location quotient has increased from 0.38 in 1995 to 0.48 in 2002. This is a significant increase, although Arizona remains more than 50 percent under concentrated in the biosciences than is the nation as a whole.

Growth in the Arizona bioscience sector is widespread, with each of the five bioscience subsectors outpacing the nation in terms of employment increase, indicating the breadth of opportunity in the sector.

The biosciences can be organized into five subsectors: drugs; organic and agricultural chemicals; medical devices and instruments; hospitals and laboratories; and bioscience research and testing. Examining these five subsectors reveals that Arizona employment growth has exceeded the national pace in each of the five bioscience subsectors between 1995 and 2001, in several cases by a large margin. For instance, growth in organic and agricultural chemicals was 186.6 percent higher in Arizona than in the nation, and employment expansion in medical devices and instruments was 45.4 percent higher (Table ES-1). Excluding hospitals and laboratories, Arizona's bioscience sector posted a six-year employment gain of 79.4 percent, compared with 28.3 percent for the entire nation.

Table ES-1. Arizona Bioscience Subsector Concentrations and Growth Rates

Subsector	2001 Employment	Location Quotient	%-point Difference between AZ and U.S. Empl. Growth '95-'01
Hospitals & laboratories	62,775	0.78	16.0
Medical devices & instruments	4,141	0.60	45.4
Organic & agricultural chemicals	1,896	0.70	186.6
Drugs	1,601	0.23	2.6
Research & testing	1,463	0.59	39.6
BIOSCIENCE SECTOR	71,876	0.72	17.3

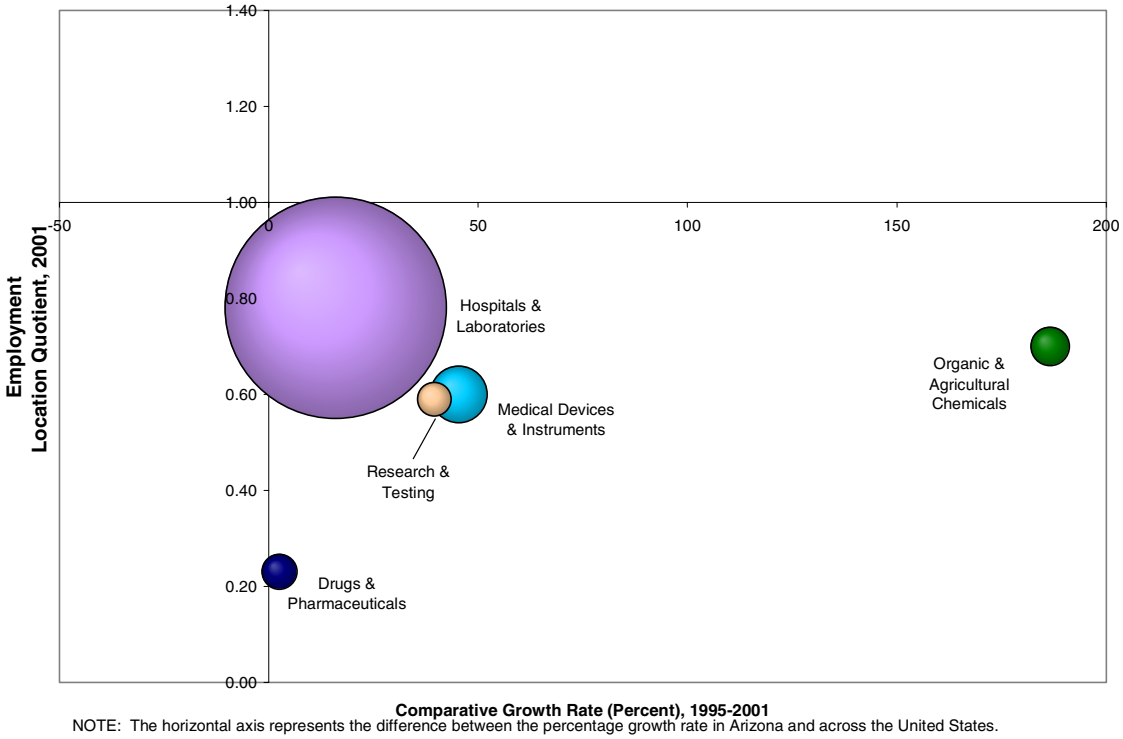
However, Arizona is 28 percent less concentrated in the biosciences overall than the rest of the nation. None of the bioscience subsectors exhibits a location quotient larger than 0.78, illustrating that Arizona lags the national level of bioscience industry presence across all of the subsectors.

Overall, Arizona's bioscience subsectors are in an emergent period, possessing certain specific strengths, sustaining remarkably rapid growth, but not as yet transformed into a fully mature economic sector. To provide a visual comparison of their various characterizations, Figure ES-1 classifies the five Arizona bioscience subsectors according to employment size, comparative growth rate, and relative concentration. The area of each disk corresponds to

[2] Excludes the hospital and laboratory subsector.

the amount of employment in that subsector. Each of the five bioscience subsectors falls into the bottom right-hand quadrant of the graph, with lower concentrations but faster employment growth rates than across the United States, thereby representing an emerging strength. Vibrant, mature sectors, those that have a greater concentration than the nation while still maintaining a faster growth rate, are found in the upper right-hand quadrant. From a policy standpoint, the goal is to move emerging industry sectors found in the lower right-hand quadrant into the upper right-hand quadrant.

Figure ES-1. Characteristics of Arizona Bioscience Subsectors



NOTE: The horizontal axis represents the difference between the percentage growth rate in Arizona and across the United States.

Arizona's existing and emerging strengths in electronics, information, optics, and materials represent an advantage for its efforts in the biosciences. These areas are increasingly converging with the biosciences, resulting in new technologies that provide the state with niche market opportunities around technology convergence.

The trend toward convergence of technologies in electronics, information, optics, materials, and the biosciences creates a potential competitive advantage for Arizona. The existence of a strong information technology cluster in the state could provide a nucleus for achieving the needed critical mass in the biosciences. Experts widely agree that these areas will converge, thereby producing a new generation of technological products that embody elements of all the fields. The application of electronics, optics, and materials to biotechnology products has been evolving rapidly; and the convergence of the biosciences and information technology has led to the emergence of companies bridging the health care and Internet economies. Arizona is well positioned to benefit from these trends.

ARIZONA'S BIOSCIENCE RESEARCH BASE

Despite a sizable base, Arizona is behind in the bioscience research arena.

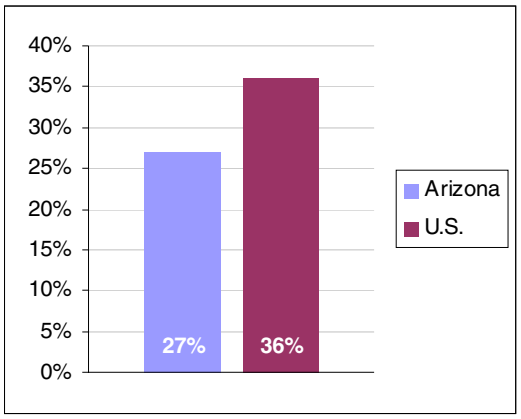
The biosciences account for $229 million of university research in Arizona, or 44 percent of the university research base in the state. This falls far short of the national average of 57 percent that biosciences account for of total university research. Not surprisingly, Arizona's national ranking in university-based bioscience research is 27th in the nation, compared with its overall research ranking of 21st. Furthermore, total bioscience research grew only 27 percent in Arizona from 1996 to 2000, compared with 36 percent for the nation, meaning Arizona is losing market share of national research dollars. More startling is the fact that Arizona's growth rate was less than every other benchmark state.

Benchmark Growth Rates

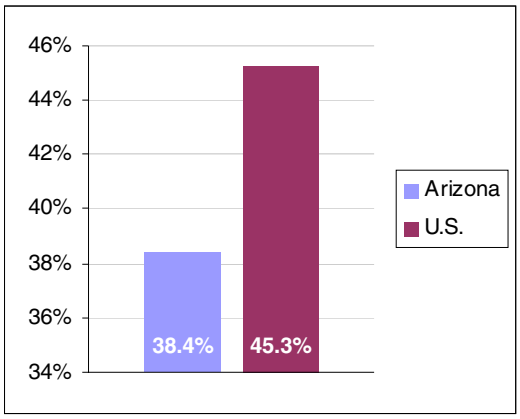
- Utah – 64.3%
- San Diego – 52.4%
- North Carolina – 42.0%
- Texas – 41.3%
- Colorado – 40.9%
- United States – 35.7%
- Washington – 33.8%
- Oregon – 32.1%
- Oklahoma – 30.5%
- Georgia – 29.2%
- Arizona – 27.5%

NIH funding—the gold standard of biomedical research funding, which includes funding to non-university entities—is also lagging in the State of Arizona (Figure ES-2). For FY 2001, Arizona received $117 million in NIH research funding, placing the state 27th in the nation. Growth in NIH funding from 1997 to 2001 stood at 38.4 percent in Arizona, compared with 45.3 percent for the nation.

Figure ES-2. Arizona is Lagging Growth in Bioscience Research in Late 1990s



University Bioscience Research Growth from 1996 to 2000



NIH Bioscience Research Growth from FY 1997 to 2001

Arizona's research institutions and medical centers have key core competencies in the biosciences that can be leveraged to establish platforms in which Arizona can gain national prominence over the next five years.

Battelle undertook both a research core and technology platform competency analysis, including quantitative and qualitative reviews of research strengths, existing and emerging, on which Arizona can build its bioscience base. Research core competency refers to those research areas where both concentration of activity and excellence are demonstrated by having

- A significant number of bioscience-related research grants awarded through rigorous peer-review processes such as those at NIH, National Science Foundation (NSF), and the U.S. Department of Agriculture (USDA).
- A broad base of principal investigators, along with prominent biomedical researchers who hold multiple peer-review grants.
- Substantial level and impact of publications.

The analysis revealed that Arizona has key core competencies around which to build bioscience technology platforms. Arizona has a strong core of expertise in neurological sciences (e.g., Alzheimer's, epilepsy) within its universities and medical centers; expertise in cancer research, particularly in the area of advancing innovative new cancer therapies (e.g., pancreatic, colon); and strengths in the physical sciences, which provide a strong base upon which to pursue bioengineering applications (e.g., imaging, prosthetics). Four other platforms that offer the potential for growth over the long term are primarily disease-specific: infectious diseases, agricultural bio-technology, asthma, and diabetes. Table ES-2 provides a summary of technology platforms that offer the greatest potential to build Arizona's bioscience base.

Near-Term Technology Platforms

- Neurological sciences
- Cancer therapeutics
- Bioengineering

Long-term and Niche Technology Platforms

- Infectious Diseases
- Agricultural Biotechnology
- Asthma
- Diabetes

Table ES-2. Technology Platform Linkages Across Core Competencies: Current and Emerging

Technology Platform	Basic Research	Enabling Technology	Applications
Areas Judged by Battelle to Have Near-Term Growth Potential Over Next Five Years			
Neurological Sciences	Neurobiology	Neural Engineering Motor Control Imaging Clinical Research Insect Science	Alzheimer's Disease Parkinson's Disease Epilepsy Rehabilitation
Cancer Therapeutics	Genomics (with new IGC/TGen)	Drug Discovery Clinical Research	Anticancer Drugs Pancreatic Cancer Colon Cancer Environmental Links to Cancer
Bioengineering	Physical Sciences	Bioengineering Optics Materials Analytical Chemistry Electronics Imaging Computer Science	Imaging & Diagnostics Implants Prosthetics Robotic Systems
Areas Judged by Battelle to be Opportunities for Future Development			
Infectious Diseases	Microbiology	Plant Vaccine Development Ecology & Evolutionary Biology	Anthrax, Plague, and Other Pathogens Plant Vaccine Development Valley Fever
Ag-Biotech	Plant Genomics		Crop Development Nutraceuticals
Asthma	Genetics	Clinical Research	Asthma
Diabetes		Clinical Research Stress Research	Diabetes

From electronics to optics, Arizona has proven it can transform itself into national research prominence in non-bioscience research areas and, with it, enjoy the benefits of sharing in new economic drivers. In recent decades, Arizona has established itself as a national leader in key areas of natural science research, particularly astronomy, other physical sciences, and earth sciences/ecology. If Arizona's research universities can replicate the tremendous success they have had in the natural sciences, then the state's research universities can reverse the recent period of slower growth in their overall research growth relative to the nation that has occurred in the late 1990s. Focusing on the biosciences can have a substantial impact on Arizona's research base.

ARIZONA'S COMPETITIVE POSITION

The San Francisco Bay Area, Boston, the Baltimore/Washington region, the New York/New Jersey metro area, and San Diego are generally regarded as the nation's premier bioscience centers. An examination of the factors that have enabled these regions to succeed in growing their bioscience bases shows that they share a number of characteristics. They include

Key Success Factors

- Engaged universities with active leadership
- Intensive networking across sectors and with industry
- Available capital covering all stages of the business cycle
- Discretionary federal or other R&D funding support
- Workforce and talent pool on which to build and sustain efforts
- Access to specialized facilities and equipment
- Stable and supportive business, tax, and regulatory policies
- Patience and a long-term perspective

- ***Engaged universities with active leadership.*** An outstanding research university is required to become serious about the biosciences. But, it takes more than simply research stature. It requires the capability to engage industry, directly or indirectly, to convert this intellectual knowledge into economic activity. To do so requires one or more of a region's research universities committed to engage with and help build and sustain a bioscience community locally. The leadership of Arizona's universities has demonstrated a willingness to collaborate in support of developing the state's bioscience sector and is initiating policies and programs to improve technology transfer and commercialization. These are important first steps in creating the type of university-industry relationships found in other leading bioscience centers.
- ***Intensive networking across sectors and with industry.*** As many observers of high-tech clusters have noted, the most successful clusters facilitate extensive and intensive networking among technology companies and their managers and employees. In a very few leading communities like Silicon Valley, this networking has occurred naturally, with formal organizations like Joint Venture-Silicon Valley coming only later. However, in the vast majority of American regions, such organizations need to be built from the ground up; otherwise, the desired degree, scale, and intensity of networking will not occur. Arizona does not yet have a critical mass of bioscience companies or sufficient networking and mentoring.
- ***Available capital covering all stages of the business cycle.*** Leading bioscience regions share one characteristic: they are home to a venture capital community that is both oriented toward early-stage financing and committed to local investment. Having state-based local venture capital funds with experience investing in bioscience companies is critical. It is also critical to have financing available for each stage of development from early-stage, proof-of-concept, and prototype development to product expansion and later-stage venture financing. While a number of Arizona-based venture funds exist, several of which are investing in bioscience companies, a gap in pre-seed/seed stage funding for bioscience companies is generally conceded.
- ***Discretionary federal or other R&D funding support.*** To build generic R&D assets into an effective attractor of technology investment requires leverage of substantial, ongoing, external, discretionary funding. Technology leaders like Silicon Valley, Route 128 in the

Boston area, and San Diego were able to leverage decades of heavy defense contracting, while Baltimore/Washington leveraged growing congressional support of federal laboratories owned by NIH, the National Institute of Standards and Technology (NIST), and the Food and Drug Administration (FDA). In the absence of massive federal or corporate investment, most regions must use state funding as a lever for acquiring strategic external investments. The premise behind the investments made in TGen and the IGC is that additional federal bioscience funding will be attracted to Arizona.

- ***Workforce and talent pool on which to build and sustain efforts***. Like any knowledge-based industry, bioscience companies need a supply of qualified, trained workers. To meet the demands of newly emerging fields, new curricula and programs need to be developed by educational institutions working in close partnership with the bioscience industry. In addition to having world-class researchers, successful bioscience regions have an adequate supply of management, sales, marketing, and regulatory personnel experienced in the biosciences. While Arizona's universities and community colleges are producing graduates with degrees in the biosciences and bioscience-related fields, it is difficult to find managers and other workers experienced in the biosciences.
- ***Access to specialized facilities and equipment.*** Facility costs are among the most significant expenses of a new bioscience firm. These firms need access to wet-lab space and specialized equipment. Since most bioscience firms initially lease space rather than purchase it, an available supply of facilities (such as privately developed multitenant buildings) offering space and equipment (such as incubators and accelerators) for bioscience companies is critical. Arizona lacks bioscience incubators, accelerators, and research parks and has inadequate wet-lab facilities.
- ***Stable and supportive business, tax, and regulatory policies.*** Bioscience companies need a regulatory climate and environment that encourage and support the growth and development of their industry. Tax policies that recognize the long development cycle required to bring new bioscience discoveries to the market can provide additional capital for emerging companies, as well as ensuring an even playing field in state and local tax policies between older, traditional industries and emerging industries such as the biosciences. Arizona's tax structure needs to be comprehensively reviewed to ensure that it has the incentives in place to encourage private sector bioscience investment and the growth of the industry.
- ***Patience and a long-term perspective***. One final lesson from every successful technology community is that success takes time. Silicon Valley and Route 128 trace their origins in electronics to the 1950s and in life sciences to the 1970s. Research Triangle Park represents a 50-year strategy that has only recently found its footing in the biosciences and is still working to develop full capability in the entrepreneurial sector. In contrast, Maryland has emerged as a major bioscience center in 12 to 14 years. While this may indicate that the time required to become a leading bioscience center can be shortened, it must be recognized that such development cannot be accomplished in a year or two or around a single project. It requires a long-term effort.

Table ES-3 summarizes how Arizona compares to best practice bioscience regions on the key success factors.

Table ES-3. Comparison of Arizona to Best Practice States and Regions on Key Success Factors

Factors of Success	Best Practice States/Regions	Arizona Situation
Engaged Universities with Active Leadership	✓ Universities are engaged in economic development and committed to technology transfer ✓ Have created vehicles for technology commercialization	✓ The leadership of Arizona's universities is committed to developing the biosciences and has entered into partnerships such as TGen ✓ Improvements have been made in technology transfer and commercial-ization, but greater investment is needed in vehicles for technology commercialization
Intensive Networking	✓ Active technology intermediary organizations provide a focal point for the state's biotechnology efforts ✓ These organizations play a critical role in networking academic, industry, government, and nonprofit groups, encouraging cross-fertilization of ideas and opportunities that lead to joint endeavors	✓ There are no active, professionally staffed industry organizations that have the ability to provide networking opportunities at the scale and intensity necessary to promote the emerging bioscience firms ✓ The state's existing bioscience cluster organizations are still in an early stage of development after several false starts
Available Capital	✓ Best practice states and regions have created programs to address the commercialization, pre-seed, and seed financing gaps to help establish and build firms ✓ Active informal angel networks investing in the biosciences ✓ Investors include private, philanthropic, and public entities	✓ A number of Arizona-based venture funds exist, several of which are investing in bioscience companies ✓ A gap in pre-seed/seed funding stage is generally conceded ✓ Limited angel networks are investing in the biosciences
Discretionary R&D Funding	✓ Every major technology region in the U.S. has received significant federal discretionary funding ✓ One or more federally designated centers exist that serve as anchors for the state or region's bioscience base	✓ Market share of NIH funding awards has decreased ✓ Limited success exists in obtaining federally designated bioscience centers ✓ Successful effort to attract IGC and TGen represents major accomplishment
Talent Pool	✓ Talent increasingly provides the discriminating variable for states and regions to build comparative advantage ✓ Educational institutions at all levels responsive to training students to meet the needs for bioscience workers at all skill levels including scientists, technicians, and production workers	✓ Arizona graduates are in excess of bioscience jobs available ✓ Strong interdisciplinary efforts exist at universities ✓ Strong community college system is offering increased curricula in the biosciences ✓ Weak K-12 system will limit ability to produce students who will pursue bioscience careers

Table ES-3. Comparison of Arizona to Best Practice States and Regions on Key Success Factors (continued)

Factors of Success	Best Practice States/Regions	Arizona Situation
Specialized Facilities and Equipment	✓ Leading bioscience regions have private markets that provide facilities offering space for bioscience companies ✓ Specialized bioscience incubators and research parks are common ✓ Access to specialized facilities and equipment, such as core labs, and animal facilities, is readily available	✓ Wet-lab space is insufficient ✓ No specialized bioscience research parks exist ✓ Incubator and accelerator space for bioscience companies is limited ✓ Knowledge of university equipment and facilities that could be accessed by firms is lacking
Supportive Business Climate	✓ Incentives to encourage growth of technology-driven firms through modernized economic development tool kit ✓ Tax structures generally leveled to treat technology-driven and manufacturing firms evenly ✓ Established brand name/image around technology themes	✓ Arizona has few economic development assistance programs to attract, retain, and grow bioscience firms ✓ Arizona's tax structure is not favorable for the development of a technology-based economy ✓ Arizona's affordability, regulatory environment, and access to resources are better than on either coast ✓ Arizona does not have an image or brand as a high-technology center
Patience and Long-term Perspective	✓ Building a critical mass of bioscience firms takes many years or even decades ✓ While the early technology pioneers took 25 years to develop, more recent examples such as Maryland and San Diego took 12 to 14 years to mature	✓ Arizona does not have a history of long-term state investment in technology development ✓ Development of successful partnerships to pursue IGC and TGen suggest that public and private leaders are beginning to make a long-term investment to building Arizona's bioscience base

The Battelle team also identified the strengths, weaknesses, opportunities, and threats (SWOTs) facing Arizona in its effort to position itself in the biosciences. This was accomplished through interviews, small group discussions, several focus group discussions, review of other studies, and collection of secondary data. The findings from the SWOT analysis are presented below.

Strengths

- Small but rapidly expanding number of bioscience companies
- State and regional leadership engaged in and supportive of the biosciences—TGen, IGC, the Biotech Institute (UA), the Medical Research Building (UA, COM), etc..
- Strong history of entrepreneurship
- Business environment conducive to development
- High quality of life in terms of cultural and recreational amenities, climate, and affordability
- Major player in basic research areas complementary to the biosciences
- Existing state support for bioscience research
- Community colleges and universities offering bioscience curricula

Weaknesses

- Private sector base not heavily concentrated in the biosciences
- Low-performing K-12 educational system
- Losing market share of national bioscience research funding
- No strong tradition of commercializing technology or encouraging entrepreneurship by universities
- State lacks necessary ingredients for a bioscience entrepreneurial culture
- Insufficient bioscience-focused venture capital and angel investors
- Few economic development assistance programs and lack of public support for higher education
- Unfavorable tax structure
- Severe budget constraints
- Business service providers not strongly specialized in the biosciences
- No image as a high-tech center
- Lack of skilled bioscience workers
- Insufficient wet-lab space

Opportunities

- Arizona well positioned to grow its bioscience sector in niche market areas, particularly neurological sciences, cancer therapeutics, and bioengineering
- Increased federal funding for bioscience research provides opportunity to capture larger share of bioscience research dollars
- Arizona has existing medical, health, and academic resources on which to build
- A focus on translational research can create a unique niche for Arizona's bioscience base
- Arizona's educational institutions are increasingly producing more graduates in the biosciences
- Matchmaking services and support for critical mass of bioscience firms
- Growing commitment to technology commercialization at the state's research universities
- State's investments in TGen/IGC could be leveraged to create and enhance partnerships with bioscience companies
- Opportune time for bold action
- Proximity to other markets provides a unique comparative advantage, e.g., San Diego and Mexico
- Opportunity to create a bioscience corridor—Flagstaff to Tucson

Threats

- Other states are aggressively pursuing bioscience development
- Other universities are pursuing biosciences as a key area of focus for their future
- Lack of early-stage equity capital may deter entrepreneurial start-ups from starting or growing in the state
- Lack of support for emerging bioscience companies may result in their decision to move out of the state
- Arizona's leaders may have unrealistic expectations and fail to recognize that developing the biosciences will require a patient and long-term commitment

SITUATIONAL ANALYSIS

Arizona's challenges in building its bioscience base include the following:

- Strengthening its bioscience research infrastructure and achieving higher education research excellence
- Developing a critical mass of bioscience companies
- Mobilizing public and private sector leadership and improving citizen knowledge and understanding of the biosciences and their impact on both economic development and the health of Arizona's citizens.

Strengthening the Bioscience Research Infrastructure and Achieving Higher Education Research Excellence

The combination of increased competition from other states, Arizona's current rankings on and success in securing federal biosciences research dollars, and its current status as a third-tier or lower state in the biosciences means that it must find ways to rapidly build its research capacity and, as it does, capture more federal and other leveraged dollars. Sufficient public sector funds for "bricks and mortar" investments, e.g., capital investments, are part of the gap to be filled; but, the gap is broader than that. It also means sufficient public sector operating funds to recruit and attract Eminent Scholars; to offer competitive recruitment packages for emerging, young, talented biosciences faculty; and to build core labs and facilities that are competitive with other academic health and university research centers across the country.

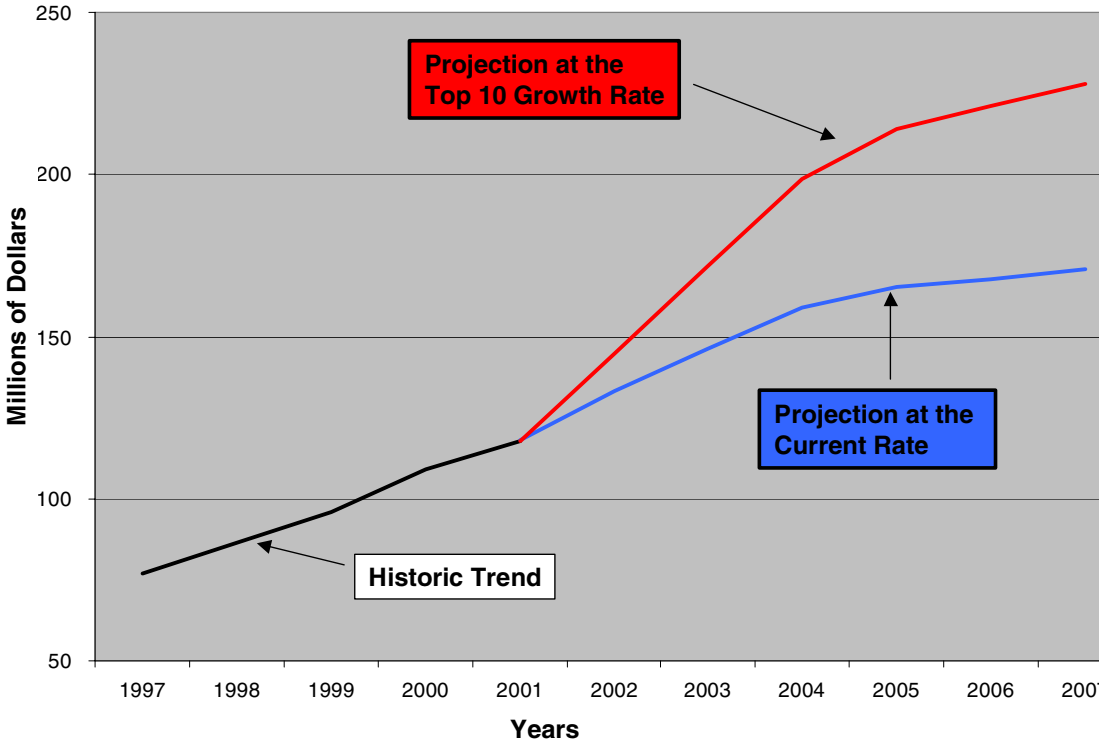
To address research infrastructure, Arizona must

- Focus on its core research capabilities and the platforms of neurological sciences, cancer therapeutics, and bioengineering over the coming five years.
- Work through multi-institutional collaboration, taking advantage of capabilities across research universities, hospitals and medical centers, and other research organizations to "jumpstart" Arizona, which is currently in a "catch-up" position.

Figure ES-3 projects Arizona's total NIH funding by the year 2007 if current trends continue. Whereas Arizona might see an increase in NIH funding from the current $118 million to $174 million, an increase of $56 million, Arizona would still place further behind other leading states. Alternatively, if Arizona is able to equal the growth rate in NIH funds of the top 10 states over the next five years, its NIH funding can increase by approximately $100 million to within the range of $214–$222 million. Arizona's performance goal should be to

> ***Achieve a rate of funding growth from the NIH equal to that of the top 10 states in NIH funding historically—increasing Arizona's NIH funding totals from $118 million in FY 2001 to $218 million in FY 2007.***

Figure ES-3. Projection of Arizona Total NIH Funding (FY 2001 to 2007)



Reaching this NIH performance objective will require corresponding investments by Arizona's research organizations in facilities, core laboratories, research faculty and support staff, and start-up packages to recruit such researchers and scholars. Table ES-4 lays out the financial implications for every $100 million in NIH funding achieved, based on national figures for costs of construction and recruitment as calculated by Battelle.

Table ES-4. Requirements to Support $100 million in NIH Funding

Estimate of One-time Requirements and Costs in Space, Research Groups, and Start-up Packages for Supporting Additional $100 Million in NIH Funding		
Estimate of	**Key Assumptions**	**Requirements**
Space Needs	For every additional $225 of research funding, need additional sq ft of space	444,444 sq ft
Space Costs	Costs $300 per sq ft for construction of basic research labs, not including core labs	$133 million
Core Research Labs	May include structural biology, micro-array facilities, animal facilities, etc.	$25–$50 million
New Research Groups	$900,000 in NIH annual funding per research group	111 research groups including senior PI, assoc. faculty, post-docs, research fellows
Start-up Package Costs	$2 million for start-up packages	$222 million, including equipment, supplies, etc.
Total One-Time Costs		**$380–$405 million**

Note: In addition, there will be ongoing operating costs for facility and for a portion of faculty salaries.

TGen and IGC represent a first installment in addressing the need to secure both additional federal research funds and funds for facilities, equipment, and other research infrastructure. These two organizations will increase the flow of federal NIH funds to Arizona both by recruiting researchers, who will bring funding with them, and by improving the capabilities of Arizona's existing research organizations to compete more successfully for NIH awards. The $90 million contributed by state, private sector, philanthropic, and university sources to attract TGen/IGC to Arizona will help Arizona partially meet the earlier-stated goal of an additional $100 million annually in NIH funding (perhaps by 25 percent). It will also help the state to partially address the additional $380–$450 million that will be needed around technology platforms to attract these federal funds.

Addressing Technology Commercialization and Building a Critical Mass of Bioscience Firm

The economic and gap analysis identified a range of issues that must be addressed concurrently with efforts to build a strong bioscience research infrastructure to turn this research into technology and realize the benefits commercialized in bioscience-related products and processes in the state, the nation, and the world. Areas such as the talent pool for the biosciences, capital gaps to finance and develop bioscience firms, space needs of such firms, networking and building an entrepreneurial culture, and educating the public and citizenry on the biosciences must be addressed as part of this Roadmap Alliance. Figure ES-4 identifies key gaps that must be addressed to grow Arizona's bioscience base. Figure ES-5 shows proposed actions that could be taken to address these gaps.

Figure ES-4. Arizona's Key Gaps Along the Life Science Development Continuum

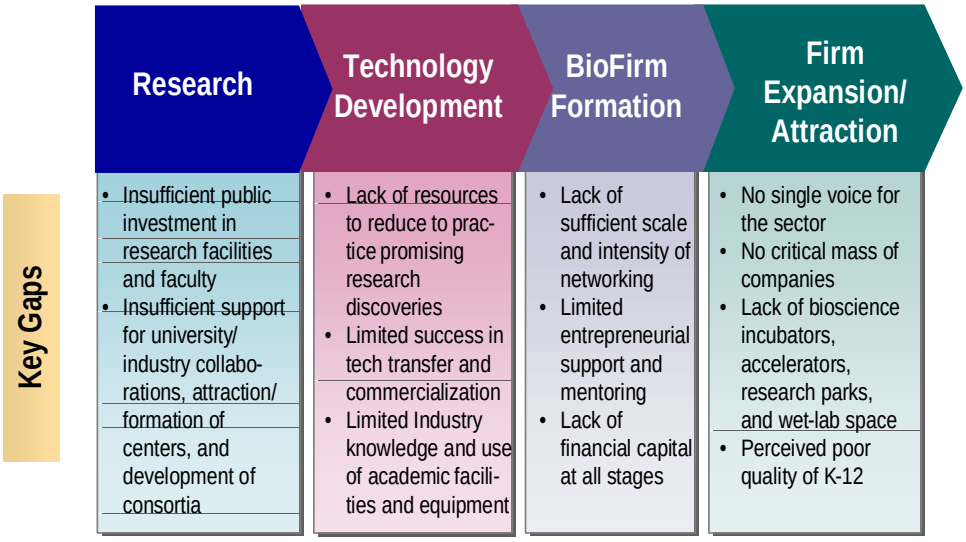
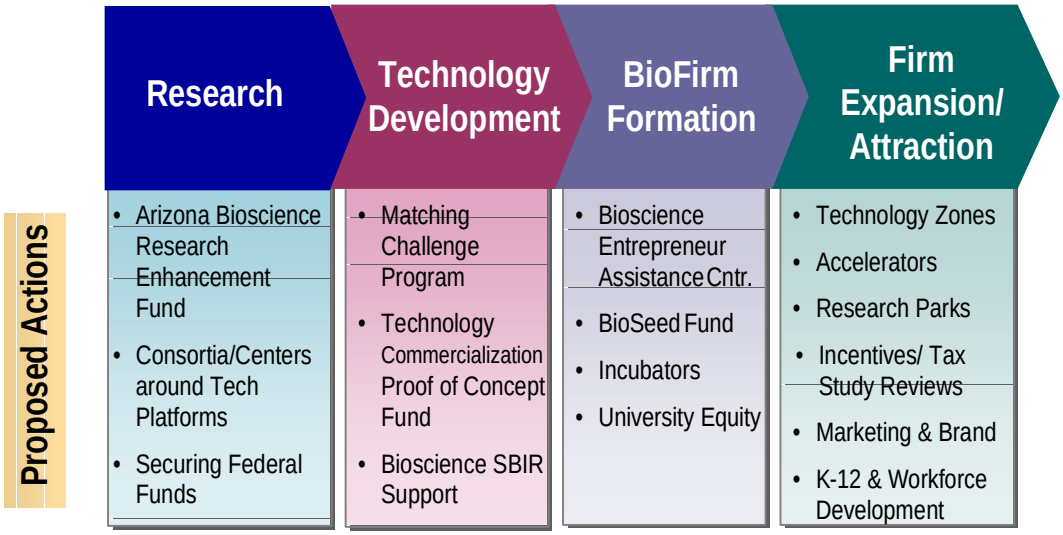


Figure ES-5. Proposed Actions to Address Key Gaps Along the Life Science Development Continuum



Mobilizing Private and Public Leadership and Increasing Knowledge and Understanding of the Biosciences

The state's current efforts remain fragmented and disorganized in the biosciences. Industry leadership is divided among multiple organizations. Connectivity with higher education varies among industry segments. Great differences exist among the state's public universities in their management of intellectual property and its commercialization. While entrepreneurship in general is strong in the state, it has not been strong among bioscience-talented individuals.

Because of the need to sustain efforts to build a regional or state bioscience base over the long term, committed leaders, i.e., champions, must step forward in the state to help lead efforts to address barriers and gaps, secure research and other funds, and market and sell Arizona as a state where biosciences is good business**.** Building a committed strategic leadership alliance of private, public, philanthropic, and capital sources will be needed to ensure that this Roadmap and the strategies proposed in it are implemented.

STRATEGIES AND ACTIONS

Four strategies are proposed to develop Arizona's bioscience research base and build a critical mass of bioscience companies.

- **Strategy One***: Build the state's research infrastructure of outstanding talent and modern facilities and equipment around selective technology platforms and core competencies.*
- **Strategy Two:** *Build a critical mass of bioscience firms by increasing the birthrate and reducing the death rate of Arizona's bioscience firms and encouraging the commercialization of research discoveries.*
- **Strategy Three:** *Offer a business climate and environment that supports, sustains, and encourages the growth of bioscience enterprises, small and large, to start, expand, and remain in Arizona.*

- **Strategy Four:** *Encourage the state's citizens to become a more informed citizenry in the biosciences and encourage young people to explore and pursue scientific and technical careers.*

These four strategies, and the proposed 19 actions they encompass, are outlined in Table ES-5. Implementation of these strategies and actions is anticipated over a five- to 10-year period. *Immediate* actions should be undertaken as soon as possible, *short-term* priorities should be undertaken in the one- to three-year period, *mid-term* priorities should be implemented in the three- to five-year time period, and *long-term* in the five- to 10-year time period.

Table ES-5. Summary of Proposed Strategies and Actions for the Roadmap Alliance

Strategy	Action	Priority
Strategy One: Build the state's research infrastructure of outstanding talent and modern facilities and equipment around selective technology platforms and core competencies.	Establish a statewide fund (the Arizona Bioscience Research Enhancement Fund) to enhance bioscience research	Immediate
	Stimulate research collaboration among universities/hospitals/other research organizations by creating consortia, centers, and institutes in bioscience platform areas and related engineering/information technology areas	Immediate to Mid-term
	Establish a Bioscience Matching Challenge Program to connect industry and researchers and to encourage university-industry partnerships	Immediate
	Increase help to entrepreneurs to secure federal SBIR/STTR funds	Short-term
	Secure federal investments to build Arizona's bioscience capacity, including working with the state's Congressional Delegation	Immediate
	Adequately fund Arizona's public higher education system overall; and use bond financing to meet higher education's capital needs for research, laboratory, and education facilities and equipment	Short-term
	Address the need to attract top graduate students to research opportunities in Arizona	Short-term
Strategy Two: Build a critical mass of bioscience firms by increasing the birthrate and reducing the death rate of Arizona's bioscience firms and encouraging the commercialization of research discoveries.	Provide in-depth, comprehensive, entrepreneurial assistance support to start-up and emerging bioscience companies	Immediate
	Support prototype development and proof-of-concept activities from research to commercialization	Short-term
	Invest at earliest stages of firm formation through an Arizona BioSeed Fund	Short-term
	Provide wet-lab space through support of bioscience accelerators/incubators/wet-lab space in and around research parks	Short-term
	Provide a mechanism for Arizona universities to take equity in start-up companies	Immediate

Table ES-5. Summary of Proposed Strategies and Actions for the Roadmap Alliance (continued)

Strategy	Action	Priority
Strategy Three: Offer a business climate and environment that supports, sustains, and encourages the growth of bioscience enterprises, small and large, to start, expand, and remain in Arizona.	Revise state/local economic development programs and the state's tax code to support the growth, expansion, and selective recruitment of bioscience firms	Short-term
	Establish Technology Zones around existing and proposed concentrations of bioscience and other technology industries	Short-term
	Form regional bioscience technology councils as separate organizations or as part of a broader regional technology council	Short-term
	Initiate a statewide image, marketing, and business development effort to market Arizona as a location for bioscience firms	Long-term
Strategy Four: Encourage the state's citizens to become a more informed citizenry in the biosciences and encourage young people to explore and pursue scientific and technical careers.	Create capacity to understand and address health policy issues from review boards and central data banks to ethics and public policy reviews	Long-term
	Address future talent pool by making improvements in science and math in K–12 through graduate education	Long-term
	Encourage talent to remain in the state by expanding co-op and internship programs	Long-term

ROADMAP ALLIANCE IMPLEMENTATION

The bioscience sector is an important and growing part of the Arizona economy. Without directed actions to sustain and renew expansion in the biosciences, current growth rates are unlikely to be maintained by internal industry dynamics and momentum alone. Furthermore, even if present growth rates were to continue unabated, the time required for the state to reach national prominence in the biosciences is measured in decades. If Arizona is to achieve its vision for the biosciences, it must aggressively implement the strategies and actions outlined in this report. However, with limited resources, it is important to set priorities. The following section identifies critical actions that must be taken to develop Arizona's bioscience sector.

Critical Actions

The successful implementation of the following eight activities will ultimately determine whether Arizona can competitively position itself in the biosciences:

- Form the **Arizona Bioscience Research Alliance** to serve as steward for this Roadmap's implementation, as well as possible direct operational involvement in those action items that otherwise cannot be initiated without the Alliance's leadership role.
- Establish the **Arizona Bioscience Research Enhancement Fund** to provide the necessary investments in higher education research and education (e.g., endowed chairs, recruitment packages, laboratories, instruments, and faculty) for its universities to secure world-class

stature in selective platform areas in collaboration with other medical, health, industry, and nonprofit research organizations.

- Form, from this Arizona Bioscience Research Enhancement Fund and federal funds, **consortia/centers in the key technology platform areas** identified in this report—neurological sciences, cancer therapeutics, and bioengineering.
- **Pursue, in concert with Arizona's Congressional Delegation, federal funds and investments** to further build the state's research enterprise.
- Establish the **Arizona BioSeed Fund** to offer an indigenous source of pre-seed and seed investments necessary to build a critical mass of homegrown bioscience firms.
- Establish the **Arizona Technology Commercialization Prototype Development Fund** to "mine" research in Arizona's research organizations to develop products and processes used by existing companies or around which new firms can be created.
- Establish the **Arizona Entrepreneurial Assistance Center** to provide in-depth mentoring and support from seasoned entrepreneurial managers (also responsible for managing the BioSeed Fund and Technology Commercialization Prototype Development Fund).
- **Provide adequate funding, including general obligation state bond financing, for higher education research facilities and laboratories.**

The biosciences address a concern of all the state's residents—access to quality health care in an environment in which the latest treatments, diagnostics, and prevention methods are practiced daily by medical and health care personnel who are outstanding clinicians, researchers, and practitioners. In addition, the biosciences provide a way to build a stronger, more stable, and diversified Arizona economy, offering quality, well-paying jobs from technician to researcher.

Immediate Work Plan Priorities

Immediate work plan priorities are those steps the private and public sectors in Arizona should undertake in the first 12 months of strategy implementation. Several critical priorities need to be implemented right away, while others will need to be planned and allocated funds before they can become fully operational.

The following actions should be undertaken in the first year of implementing the Roadmap Alliance:

- Form the Arizona Bioscience Research Alliance to serve as steward for this Roadmap's implementation.
- Begin the process of encouraging gubernatorial and legislative support for the Arizona Bioscience Research Enhancement Fund, possibly by administratively using state general obligation bonding authority to fund facilities, labs, and recruitment packages for bioscience development in the key technology platform areas.
- Work with the philanthropic sector, state government, and higher education institutions to develop strategic business frameworks and investment plans for each technology platform area.
- Discuss and develop a concept plan and begin to build gubernatorial and legislative support for the formation of an Arizona Bioscience Matching Challenge Program.

- Prepare an annual list and a multiyear strategy of key bioscience projects and investments to submit to Arizona's Congressional Delegation.
- Resolve the approach necessary to enable the state's public research universities to take an equity participation in licenses.
- Develop a prospectus for the entrepreneurial assistance center.
- Begin discussions with in-state angel and other wealthy investors, the state's private and public pension and venture funds, and leaders in industry and higher education to secure capital commitments for the Arizona BioSeed Fund.
- Develop stronger regional bioscience councils, either stand-alone or part of a broader technology council, and increase the scale of networking activities for the bioscience industry.
- Use existing state and regional promotion and marketing funds to focus on making Arizona a more recognized center in the biosciences and develop Arizona's "brand name" in the biosciences.
- Begin planning for an expanded co-op and internship program**.**

Organization and Structure for Implementation of the Roadmap Alliance

State science and technology initiatives are most effective when they are executed on a bipartisan basis, with strong executive and legislative branch support, involvement, and cooperation. States such as Pennsylvania, New York, Georgia, Maine, Maryland, and North Carolina have been successful with their science and technology investments because their efforts have been broad based, they have mobilized private sector champions behind them, and their initiatives have become institutionalized into the state and regional fabric of both economic development and higher education.

This Bioscience Roadmap proposes a set of strategies and actions that involve many private and public sector organizations. Directing this Bioscience Roadmap of and serving as steward are both sensitive and critically important to the success of the entire set of strategies. Therefore, Battelle suggests that the most appropriate approach is to form the Arizona Bioscience Research Alliance (ABRA) to both coordinate efforts and, where necessary and appropriate, directly operate programs such as the Bioscience Research Enhancement Fund, the Bioscience Matching Challenge Program, and/or the Entrepreneurial Assistance Center. One or more of these programs might be more appropriately managed by a newly created nonprofit or for-profit, such as the Entrepreneurial Assistance Center, which also would co-manage the BioSeed Fund and the Technology Commercialization Prototype Development Fund.

It is Battelle's recommendation that ABRA should be legally organized as a private, nonprofit corporation with a majority of its board from industry.

ABRA also is expected to work closely with the Arizona Department of Commerce, the Arizona Board of Regents, and the state's three public research universities and their leadership to ensure that related science and technology programs are linked to its efforts. ABRA will focus on both research excellence and technology commercialization around the technology platforms laid out earlier.

Overall, Arizona's bioscience delivery system will be composed of the following key components:

- The Arizona Bioscience Research Alliance
- Entrepreneurial Assistance Center, co-managing the BioSeed Fund and Prototype Development Fund
- Technology-led trade and civic organizations in each region, working together on statewide needs and issues
- Arizona's higher education anchors, including research universities, comprehensive universities, and community colleges.

Arizona cannot stand still and remain economically viable while other states make key investments in their future around the biosciences. The key to the success of this Roadmap is sound execution that requires talent, commitment, and perseverance. Strategies can be successful only if implementation is achieved.

Measures of Success

Performance measures and goals are proposed below, with actual monitoring undertaken on an ongoing basis through the Arizona Bioscience Research Alliance to determine to what degree performance objectives are being accomplished. Key measures to monitor progress might include the following:

- Increase in bioscience R&D funding to Arizona research institutions at a rate equal to or greater than the historical growth rate of the top 10 states over the next five years.
- An increase in NIH funding from $118 million to $214 million by 2007.
- Start-up and survival rates of Arizona bioscience firms exceeding the average rates for benchmark states as identified in this Roadmap.
- An increase in the concentration rate and thus degree of specialization relative to the nation in at least two industry segments (LQ >1.20) by 2007.
- Leveraging of federal and other dollars at least three times for every $1 in Arizona support.
- Dollars of bioscience venture investments to Arizona-based firms to total at least $100 million in 2007.
- Arizona university-related start-ups/revenue dollars to exceed the top quartile ratio of all U.S. universities by 2007.
- Implementation progress on the actions laid out in this Roadmap—at least 70 percent with substantial action after three years, and 90 percent within five years.

In addition to these outcome and impact measures, Arizona should update this Roadmap every three to five years to adjust to changing economic conditions.

Resources Required

Table ES-6 shows, for each action, the priority of the action and the annual and one-time costs. The successful effort to raise funds for TGen illustrates the level of stakeholder involvement and support across a number of private and public organizations that will be needed to successfully implement this Roadmap.

Table ES-6. Arizona Roadmap Resource Requirements

Action	Priority	Annual Cost	One-time Costs	Leverage Ratio
Arizona Bioscience Research Alliance	Immediate	$400,000–$500,000	0	N/A
AZ Bioscience Research Enhancement Fund	Immediate		$42 million/year for 8 years	1:9
Research collaborations, consortia, centers, and institutes	Two Immediate initiatives (TGen/IGC and ARC) Third effort years 4–6 or sooner	$10 million/year in non-federal operating support	$400 million for capital projects around platforms TGen/IGC–$90 million	1:9
Bioscience Matching Challenge Program	Immediate to short-term	Initially $750,000 rising to $6 million/ year by year ten	0	1:3
Bioscience SBIR Support Program	Short-term	$400–$600,000	0	1:4
Seek federal funding with Congressional Delegation	Immediate		Goal of $170 million or more over 10 years in federal funds	1:150
Adequately fund higher education	Short-term	Use bonding authority to finance capital improvement projects		N/A
Attract graduate students	Short-term	$1.8 million/year	0	1:3
AZ Bioscience Entrepreneur Assistance Center	Immediate	$400–$600,000	0	N/A
Bioscience Technology Commercialization Prototype Development Fund	Short-term	0	$12–$15 million every five years	1:5

Table E-6. Arizona Roadmap Resource Requirements (continued)

Action	Priority	Annual Cost	One-time Costs	Leverage Ratio
AZ BioSeed Fund	Short-term	0	Up to $70 million in private and other support	1:9
Incubators/accelerators and research parks	Short-term	Operating support for incubator of $150–$250,000 annually for first 18–36 months for three facilities	$50-$70 million for three incubators/ accelerators $40–$50 million for research park and related infrastructure	1:5
Mechanism to allow universities to hold equity	Immediate	No additional costs but source of additional revenues		N/A
Comprehensive review of economic development and tax policy	Short-term	0	$500–$750,000	N/A
Technology zones	Short-term	To be determined	To be determined	N/A
Regional bioscience councils	Short-term	$250,000/ year each for two councils	0	All private
Image, marketing, and business development	Long-term	Redirect existing resources	0	N/A
Capacity to understand and address health policy issues	Long-term	$3 million a year	0	From philanthropic and other sources
K-12 education • Curriculum development • Support for science teachers • Loan forgiveness programs	Long-term	 $1–$2 million $5–$25 million	$250–$500,000	1:2
Expanded internships and co-op programs	Long-term	$200–$500,000 logistics support leveraged with significant private support	0	1:3

Economic Impact Analysis

The Arizona Bioscience Roadmap lays out a list of strategic investments across the entire continuum of bioscience development, from basic research to firm formation and attraction. This multiyear investment program, stretching over at least a decade or more, will provide the types of investments at a sufficient scale to achieve a critical mass of research around key technology platforms and, ultimately, result in a critical mass of bioscience firms populating Arizona by 2012.

Battelle's economic impact analysis indicates that the investments recommended in this Roadmap can result in the following impacts:

- **Critical Mass of Research Support.** The State of Arizona can reach a level of NIH funding equal to the historic growth rates of the top 10 states in NIH funding by 2007, resulting in $274 million of annual federal NIH funding. In addition, the investments made in research facilities, faculty, and instrumentation will attract additional funding equal to three times their costs within the next 10 years.
- **Critical Mass of Businesses and Jobs.** Arizona's non-hospital bioscience industry will grow by an additional 120 firms and create an additional 12,900 jobs by 2012. This critical mass of bioscience firms will have a multiplier effect on other business service and supplier sectors of the economy, accounting for an estimated 17,000 additional jobs in all sectors of Arizona's economy.
- **Leveraged Investments.** For specific investments in the Bioscience Roadmap designed to leverage other financial support, every $1 that Arizona's private and public sectors provide is estimated to leverage $6.26 in other investments.

CONCLUSION

Arizona must play "catch up" to other states if it is to become a major southwestern state in the biosciences. The first effort of success—the attraction of TGen and IGC to Arizona—will need to be replicated in other technology platform areas identified in this Roadmap. Focusing on a few platforms, rather than trying to spread limited resources across multiple areas, is one effective way for Arizona to indeed catch up. Technology commercialization must be concurrently addressed if the state is to build a critical mass of bioscience firms and to apply research to patient care and quality health care delivery.

This Roadmap lays out a comprehensive approach to accomplish this plan, with details in the full report and highlights in this executive summary. This Roadmap proposes a bioscience agenda based on private sector, market-driven needs, and recommends actions and their implementation around filling private sector gaps through industry-led private-public partnerships.

Arizona's current situation is not unique. Other states and regions once behind in the development of their bioscience sectors (including San Diego, California; Montgomery County, Maryland; Birmingham, Alabama; and Portland, Oregon) have either successfully positioned themselves as a leading bioscience region or are focusing their strategic investments to carve out a particular market niche for the future.

Abbreviations and Acronyms

ADCRC	Arizona Disease Control Research Commission
ASU	Arizona State University
ADOC	Arizona Department of Commerce
ARP	Advanced Research Program
ATP	Advanced Technology Program
BCMT	Baylor College of Medicine Technologies
CEDC	Community and Economic Development Commission
CRI	Cancer Research Institute (at ASU)
FAST	Federal and State Technology
FDA	U.S. Food and Drug Administration
GRA	Georgia Research Alliance
GSP	gross state product
IGC	International Genomics Consortium
IP	Intellectual Property
IPO	initial public offering
MCC	Microelectronics and Computer Consortium
MIPL	Multidimensional Image Processing Laboratory
MRI	magnetic resonance imaging
NAFTA	North American Free Trade Agreement
NAICS	North American Industry Classification System
NAU	Northern Arizona University
NCI	National Cancer Institute
NCTDA	North Carolina Technological Development Authority
NIAID	National Institute of Allergy and Infectious Diseases
NIDDK	National Institute of Diabetes, Digestive and Kidney Diseases
NIEHS	National Institute of Environmental Health Sciences
NIST	National Institute of Standards and Technology
NMR	nuclear magnetic resonance
OTCC	Oklahoma Technology Commercialization Center
R&D	research and development
SBA	Small Business Administration
SIC	Standard Industrial Classification

SWOT	strengths, weaknesses, opportunities, and threats
TGen	Translational Genomics Research Institute
UA	University of Arizona
USDA	U.S. Department of Agriculture