PROGRESS REPORT FOR
POSITIONING ARIZONA FOR
SUCCESS IN THE BIOSCIENCES:

OVERVIEW OF TECHNOLOGY PLATFORM STRATEGIES

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The Flinn Foundation

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June 2004

Battelle
The Business *of* Innovation

Progress Report for Positioning Arizona for Success in the Biosciences:

Overview of Technology Platform Strategies

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PREFACE

Arizona is pioneering a new and novel approach to building its long term position in the biosciences. Starting with the Biosciences Roadmap, released in December, 2002, followed with intensive interaction among scientists, clinicians, and others in development of full fledged plans for each of the near term core competencies and platforms identified in that roadmap, Arizona is positioning itself to become a significant player and major state in the Southwestern U.S. in selective, focused areas of strength.

The cross-cutting investments and specific near term technology platform plans laid out in this document show both efforts to date to think collaboratively on how Arizona can further build on its strengths, and the opportunities and needs that must be addressed if these focus areas are to fully blossom and serve as the fundamental base on which Arizona's biosciences future blooms and flourishes.

The specific contents of this report include:

Section 1:	Introduction and Summary of Key Findings
Section 2:	Scope of Strategic Plan for Technology Platform Areas
Section 3:	Overview on Platform Strategic Plans, Cross Platform Infrastructure Needs and Key Themes
Section 4:	Metrics for Success
Section 5:	Financial Plan
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No other state, to our knowledge, has taken such a fundamental comprehensive approach to not only identifying its strengths and competencies, but moving forward to develop plans across institutions to further build its research stature. While other states and regions talk about their research base, few have gone the extra mile to bring the relevant research, clinical, and business partners together.

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Section 1: Introduction and Summary of Key Findings

The Arizona Bioscience Opportunity

The biosciences are an important area of opportunity for Arizona both for raising the quality of life and for generating economic growth. The Flinn Foundation, in alliance with the state's research universities and organizations and industry, has been facilitating the implementation of a strategic Arizona Bioscience Roadmap—bringing together the breadth of stakeholders across academia, industry, government and the broader community.

The 10 year vision for the Arizona Bioscience Roadmap is to transform Arizona into:

> ***…a leading western 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.***

Key to Building Arizona's Bioscience Stature is Focusing on Select Areas

Arizona's real hope of becoming a major player in the biosciences is to focus around a few key select areas and build stature in these. The Roadmap assessment boils down to some critical themes on the importance of having specific focus:

- Arizona must play "catch up" by focusing on specific bioscience areas to build excellence;
- Arizona must continue to build on its growing bioscience base and ensure growing momentum in areas where it has the greatest potential;
- Arizona—while not the first to enter the biosciences—can build on its assets and opportunities for excellence in selective areas; and
- Having a clear focus can help position Arizona nationally and internationally, such as with the recently released NIH Roadmap.

Three Near-Term Technology Platforms Opportunities for Arizona Identified

In the formulation of the Arizona Bioscience Roadmap, considerable effort was expended to identify the focus areas around which the state's bioscience research base can be further developed and national excellence established.

Three technology platforms were identified in the Arizona Bioscience Roadmap based on their potential in the near term to best position Arizona in the biosciences, including:

- ✓ **Bioengineering research**
- ✓ **Neuroscience research**
- ✓ **Cancer research**

In addition, promising longer term opportunities were identified for Arizona in infectious diseases, agricultural biotech, asthma and diabetes, which can follow these near-term focused investments.

Need for Strategic Plans and Statewide Collaborations

The three near term platform research areas will require significant further investments in talent, research facilities, and equipment. At the same time, bioscience research organizations from across the state are already focusing on one or more aspects of these near term platforms, but in a relatively uncoordinated and non-strategic way for the state as a whole.

Without a way to bring faculty, administrators, and other stakeholders together across institutions and research organizations, Arizona will delay—at best—maximizing its capabilities in these select fields of the biosciences where Arizona can excel and where its research stature can be recognized and the economic benefits in terms of income, jobs, and careers can be enhanced.

With the support of the Council of Presidents and other higher education officials, the Flinn Foundation has engaged the broad community of bioscience research organizations from across the state to facilitate the development of comprehensive strategic plans in each of the three near-term technology platforms. Assisting the Flinn Foundation in this effort has been the Technology Partnership Practice of Battelle, who also assisted in the development of the Arizona Bioscience Roadmap.

Summary of Findings

The findings of this strategic planning effort are found in three key areas:

- Emergence of cross-cutting investment needs;
- Identification of niches for near term technology platform opportunities; and
- Financial plan

Emergence of Cross-Cutting Investment Needs

Across the technology platform areas there were many areas of common investment needs identified, demonstrating both the value for collaboration across universities and non-profit bioscience research drivers as well as the need for more developed bioscience research infrastructure in Arizona.

Supportive technical facilities and capabilities:

- Imaging facilities and technology development
- Bioinformatics
- Biostatistics and epidemiology
- Tissue repositories
- Transgenic animal facilities

Key collaborative mechanisms:

- Broadening clinical research and streamlining clinical trials processes
- Information sharing and broadening outreach and collaboration among researchers and industry
- Establishing a “Special Populations Alliance in Arizona
- Promoting technology commercialization
- Establishing more flexible funding approaches for teaming and collaboration

Identification of Niches for Technology Platform Opportunities

Each near term technology platform identified specific niches where Arizona can excel and be a national leader.

Bioengineering Niches:

- Neural engineering
- Regenerative medicine

- Rehabilitation engineering

Cancer Niches:

- Gastro-intestinal cancer
- Skin cancer
- Cancer drug discovery and development
- Cancer imaging
- Neuro-oncology

Neurosciences Niches:

- Learning, memory and cognitive disorders
- Motor systems and movement disorders

Financial Plan

A high-level comprehensive five year funding plan aligning project investment funds required with expected sources of funding reveals the following:

- Total investment of $599.5 million to $681.5 million.
- Cross-cutting enhancements are expected to reach approximately $176 million.
- Investments by Technology Platform Areas:
    - Neurosciences: $140 million
    - Cancer Research: $84 million to $126 million
    - Bioengineering Research: $201 million to $240 million
- Diversified sources of funding, including state, federal, philanthropic and industry are expected to generate more than 90 percent of the funding needed in the first five years, leaving a projected gap of $43 million to $64 million over five years.
    - Key sources to close the gap exist, such as shared equipment grants from NIH, revenues from technology commercialization and licensing and allocation of a portion of indirect costs generated from new federal grants (an allocation of 25 percent of indirect costs of new grants roughly covers the estimated gap).
- These significant investments can be sustained largely over the course of the next five years (years 6–10) by direct funding from federal grants. Thus, no new state investments are projected to support the major activities encompassed in the strategic plans for the three platform areas and cross-cutting enhancements beyond year five.
    - The expectation that the three platform areas will be self-sustaining in years 6–10 will provide Arizona with a strong foundation and enable the state to address new areas of biosciences research and development.

Section 2: Scope of Strategic Plan for Technology Platform Areas

The goal of this strategic planning process is to establish a state-wide plan of action for building excellence in each of the three near term technology platform areas. In turn, this process calls for building a statewide perspective and participation. A critical partner in this process is the Arizona Disease Control Research Commission (ADCRC), a tobacco-tax supported state agency that provides significant annual funding to Arizona biomedical researchers. The ADCRC was an active participant and supporter of this strategic planning process. By bringing together the breadth of bioscience institutions from across the state and developing a common game plan, Arizona can ensure that state investments can have a significant return and leverage a broad base of investments across all institutions in the state.

Broad-Based Strategic Planning Process

The Flinn Foundation reached out to the broad community of universities and non-profit research organizations in Arizona that were engaged in biosciences research to gain their involvement in the strategic planning process. As a result, nearly one hundred senior-level researchers and administrators from across Arizona were selected by their universities and non-profit research organizations to come together and inform and shape the development of strategic plans for the technology platform areas.

The process of engagement has involved a series of monthly meetings involving intensive discussions by the Technology Platform Committee members, along with ongoing information collection and sharing. To further inform the strategic planning process, a day-long scientific retreat for each technology platform was held, involving an even broader range of research participants from the parent organizations and elsewhere.

In October of 2003, a major bioscience symposium was held, sponsored by the Arizona Disease Control and Research Commission (ADCRC) and the Flinn Foundation, to review the draft technology platform plans. Attending this October Symposium were the members of the technology platform committees, university and non-profit research leadership, members of the ADCRC, members of the economic development community, other community leadership and other leading faculty and administrators.

Content of Strategic Plans for Each Technology Platform Area

Each Technology Platform, under the guidance of their respective Technology Platform Committees, was asked to develop a strategic plan that focuses on:

- Strategic vision and areas of focus for that technology platform area;
- Resource gaps and collaborative opportunities for that technology platform area;
- Proposed collaborative structure and organization for that technology platform area;
- Investment needs for faculty, facilities and equipment, clinical infrastructure and enabling initiatives; and

- Program and related investments priorities and implementation time frames.

Supporting the development of these strategic plans were two analyses. One was the development of an inventory of assets, namely facilities, equipment and expert staff identified through the efforts of the Technology Platform members and reporting at the scientific retreat. The other was a peer analysis conducted by Battelle, which was used to validate the strategic plan approaches identified by the Technology Platform committees. These analyses are included as appendices to each platform plan.

Section 3: Overview on Platform Strategic Plans, Cross-Platform Supportive Infrastructure and Key Themes

The ideal of a statewide collaborative effort in focused areas of bioscience development is one that is often out of reach for most states with entrenched organizations and regional rivalries. In Arizona, however, the dynamics and interests for promoting this statewide approach seem firmly in place. Arizona has displayed a unique capability to unite and focus on the biosciences in a statewide perspective. The success of the Arizona Alzheimer's Disease Center—the only statewide Alzheimer's Disease organization recognized as a center of excellence by National Institute of Health (NIH)—and the formation of The Translational Genomics Research Institute (TGen) are two outstanding examples of this statewide approach in practice.

The outcome of this strategic planning process for Arizona in the selected technology platform areas of the biosciences is not merely a collection of individual plans from each institution, but an integrated approach and focus, with required enhancements and key activities for building collaborative, multi-disciplinary research programs across organizations and technology platforms.

Cross Cutting Investment Needs

There were many areas of common investment needs identified by the three Technology Platform committees. These cross cutting needs fall into two categories:

- Specific technical facilities and capabilities that support development of each of the bioscience platforms and future platforms.
- Key collaborative mechanisms needed to enable Arizona to seize the potential of its bioscience research in advancing medical therapies, new products and bioscience ventures.

Supportive Technical Facilities and Capabilities

Among the shared technical facilities and capabilities identified by the Platform committees were:

- **Imaging facilities** – The use and development of imaging is a cross cutting strength of Arizona in the biosciences, and increasingly a critical tool for advancing bioscience research. ***Discussions across the technology platform areas indicate that Arizona's potential in bio-imaging may possibly be a significant distinguishing feature for the state across its bioscience research base, if it is further cultivated and developed.***

What is emerging is the development of an Arizona Bio-Imaging Consortium on par with the three technology research platforms. The proposed focus of this Consortium would be on "translational *in vivo* imaging and all of the basic science needed to support it." Six initial program areas have been identified:

- Human imaging research, including use in clinical trials for cohort of patients and single-site to develop new applications;
- Animal imaging;
- Novel contrast mechanisms and tracer development;
- Equipment development including novel detectors and systems for capturing images;
- Imaging analysis; and
- Training.

These six initial program areas reflect that while there are significant needs for greater availability of imaging facilities, it is also critical to recognize that imaging technology is in a constant state of development and so a complementary imaging research component is needed to ensure the state's competitive position.

In terms of access to facilities, a particular concern is the need to ensure dedicated time for human-based research, which often gets squeezed out by clinical demands. Small animal imaging is a growing area of focus as imaging technologies become critical for biomedical research. Currently there is only one such facility in the state located in Tucson, which is at or near capacity. Also, there is a need for separate human and animal research facilities, even beyond small animals, because of cross-species virus contamination. Finally, the need is not only for imaging facilities, but also for staff capacity to assist with programming and image analysis. This staffing need can be provided on a shared basis. It should be noted that this shared imaging facility infrastructure does not substitute for specific initiatives within Technology Platform areas for more research and development of advanced medical imaging systems.

In terms of advancing imaging research, there are broad-based needs—from molecular imaging to PET radiotracers to other modalities—that Arizona, with its deep strengths in optics and other key technologies, is well positioned to advance. Arizona also has strong capabilities in advancing image analysis, including advanced computational modeling and bio-signal processing.

- **Bioinformatics** – Bioinformatics is revolutionizing bioscience research, enabling use of powerful new tools that develop information on basic biological processes from genes to proteins. Particularly in the Cancer and Neuroscience platforms, researchers are actively exploiting the use of these new tools, such as micro-array analyses to genotyping. However, properly designing the use of these tools, handling the large data being generated and interpreting that data, are difficult tasks and further capacity is needed across Arizona. With the formation of TGen, Arizona has a unique resource in bioinformatics. In just a short time, significant research relationships between TGen experts and Arizona bioscience researchers are being established. To more broadly leverage the expertise of TGen, it is critical to establish a training and technical assistance

resource that can access TGen expertise even in situations when TGen is not closely linked to the specific research activity. The goal is to establish a service-oriented core facility in concert with TGen to address the full set of integrated needs from data base development, hardware and software configuration and data analysis.

- **Biostatistics and epidemiology enhancement** – Arizona has a paucity of biostatistics and epidemiology expertise to help in the design and interpretation of results from clinical research activities. Members of the Technology Platform committees have indicated that with earlier and more intensive involvement of biostatisticians and epidemiologists, Arizona bioscience researchers can improve the quality of their proposals for conducting clinical research and also provide a more rigorous basis for understanding risk factors and helping to direct future research inquiries.
- **Tissue repository** – Related to the growth of genomics and bioinformatics is the need to access tissue samples in which these research tools can be applied. Arizona is well-known for the Sun Health brain bank and other key tissue banks, but to advance future research a more comprehensive and focused approach. The approach would be statewide and expand the range of tissue samples in order to provide a broader base for analysis. In addition to specific tissue repository development identified for Arizona's individual technology platforms, consideration should be given to establishing a more comprehensive whole organ and tissue sample repository that can enable future research activities.

  Complementing these expanded tissue repository efforts would be a unique and signature statewide tissue preservation research center to provide the highest quality tissues for diagnostic and therapeutic purposes supporting all of the technology platform areas.
- **Animal facilities** – Conducting research in animal models is essential for translating most innovative discoveries towards translation into new therapies and medical practices. Across the Technology Platform areas, a strong need was expressed for additional facilities to house both small and large animals, as well as more in-state capacity to develop transgenic animal models. Existing animal facilities in the state require expansion and are not optimally distributed to serve the broad range of bioscience research facilities in the state. It was noted that many research institutions are outsourcing production of their animal models, which is causing significant delays in their research activities.

Collaborative Mechanisms for Advancing Translational Research and Commercialization

The cross cutting issues among the bioscience research platforms reached far beyond the technical infrastructure into the very fabric of promoting translational research that connects basic research with clinical research studies and commercialization support that can advance new drug therapies, medical procedures and devices into the marketplace. One important collaboration unfolding for Arizona is the development of the Arizona Biomedical Collaborative, bringing together the University of Arizona, Arizona State University and Northern Arizona University, in partnership with the major hospitals in the Phoenix region, in a downtown Phoenix facility advancing education and clinical research.

A number of specific collaboration issues were raised by the Platform committees:

Broadening clinical research and streamlining clinical trials processes. Across the Platform committees a key issue for Arizona was how to advance clinical research to take the successes from the bench to the bed, which brings up squarely the issue of "how are we going to involve clinicians." It is well recognized that there is the researcher world and the practicing physician world and they are separated by culture, focus and reward systems. Academic physicians who are committed to both worlds face unique challenges that need to be addressed.

One key opportunity where the world of researchers and MDs can and need to meet is that of advancing clinical trials activities in Arizona. Clinical trials activities are central for advancing new therapies and medical applications. Arizona today lacks sufficient mechanisms to partner across its biomedical research institutions needed to advance clinical trials in a more concerted manner. Discussions identified a need for establishing a clinical trials consortium that could facilitate and broaden the coordination of clinical trials activities across the state.

Specific types of facilitation activities the consortium might undertake include:

- Development of a community/statewide Internal Review Board (IRB);
- Clarify and strategize HIPAA issues to allow access to patient tissues, clinical information and screening for potential patient entry to protocols; and
- Broaden the involvement of physicians into clinical trials activities, especially Phase I and Phase II.

Information sharing and broadening the means for outreach and collaboration among bioscience researchers as well as with the growing base of bioscience companies in Arizona. Fundamental to the idea of enhancing bioscience platform areas is the concept of bringing together as a community the broad base of researchers found across multiple institutions and the growing community of bioscience companies in Arizona. There was a concern that the strengths of Arizona are being missed and not well understood because of the geographic dispersion of research activities across the state.

The Platform committees also raised the need to improve capacity for identifying researchers with certain types of expertise, as well as reaching out to private practice physicians to create greater awareness of resources available that can address improving medical treatments.

Establishing an Internet-based Collaboratory for the Biosciences. The Collaboratory would integrate advanced tools, such as virtual collaboration work spaces, where teams of researchers can work together on sharing test results, interpreting these results and developing papers and proposals. There would also be more typical video conferencing capabilities and web sites of researcher directories. In essence, the Collaboratory would provide a virtual community for the biosciences, which would add value to developing and to conducting research, as well as connecting academic and industry-based researchers and physicians.

Establishing a "Special Population Alliance" in Arizona. One place where the issues of broadening collaboration and advancing clinical research meet is that of working together with special population groups in the state. Arizona has a significant concentration of specialized population groups, from Native Americans to Hispanics to elderly, which have unique public health

issues and offer important insights into biomedical research. While there have been tangible successes, much more can be done, but only if a genuine partnership approach can be taken that actively involves these specialized communities at the start and ensures that they are helping to guide the effort.

For Native Americans, it is very important that researchers understand that they cannot just walk onto a reservation and do research. It takes two to three years of ground work in order to write a proposal, plus a need to be flexible and make protocol changes. It will take even longer to complete the work.

To facilitate this need for partnerships and capacity for researchers to have an accessible mechanism for working with specialized population groups, it is proposed that a Special Populations Alliance be created that would support a statewide intermediary resource allowing for a more predictable and proactive approach, without having to recreate the partnering process.

Promoting Technology Commercialization. There exists in Arizona a major need to create a more flexible, proactive capability for technology commercialization that can augment the activities in technology transfer found across research institutions and add value in further developing and marketing intellectual property. Activities would include performing market assessments, investing in proof of concept research activities and developing business plans and new ventures.

There are also a range of important public policy issues that must be addressed, including:

- Development of a more consistent, up-front understanding of how intellectual property rights, cost sharing and allocation of indirect grant reimbursements and indemnification and liability concerns are to be addressed for multi-institutional research collaborations. It was suggested that a standardized, umbrella agreement be developed to minimize the time commitment of case-by-case negotiations. Ultimately, cooperation will depend upon the establishment of trust among the parties involved. This requires getting high level leadership involved, including the Arizona Board of Regents.
- Specific IP issues will also need to be addressed. For example: a) addressing the restrictions on improving patents with additional research funding and b) improving the means for bundling inter-institutional patents needed for new company formation.

Establishing more flexible funding approaches for teaming and collaborations. At the heart of these collaborative needs expressed by the Platform committees was the need for more flexible funding mechanisms that promote the formation and support of inter-institutional research teams. There was a concern that Arizona needs a more strategic approach in which the state is a partner with institutions in pursuing significant opportunities that represent a pre-competitive phase. This approach would support the development of highly competitive research teams for federal funding and has proven success as demonstrated by the Arizona Alzheimer's Disease Research Center. Flexible funding is central to the implementation of strategic plans developed by the Technology Platform committees.

The proposed funding to support these cross cutting technical resources and collaborative mechanisms are summarized in the section on Cross-cutting Infrastructure Resources.

Overview of Technology Platform Strategic Plans: Strategic Niches, Key Enhancements and Priorities

Each of the technology platform strategic plans is quite different from the other. The distinctiveness of each technology platform's strategy plan reflects the maturity, stage of development, Arizona's relative position, and the different circumstances, organizations and opportunities found in each technology platform area.

The key elements of each technology platform strategic approach, focusing on identified niches, key investments and specific approaches are summarized below.

Strategic Niches and Priorities

One of the most difficult steps in a consensus-oriented process is identifying specific niches where Arizona can be a national competitor.

Across the Technology Platforms the following level of focus and direction is emerging.

In **bioengineering**, there was broad consensus that Arizona could best be a national leader in this emerging field by focusing on building up its position in three key application areas and creating "go to" Centers of Excellence with major hubs and satellite offices to establish a statewide collaboration in bioengineering. The three key application areas are:

- Neural engineering;
- Regenerative medicine; and
- Rehabilitation engineering.

These three application areas in bioengineering are linked thematically in that they focus on developing materials, devices or systems to replace diseased or damaged body parts, or enhance the capabilities and improve the quality of life for individuals with physical and cognitive impairments.

Moreover, these three lead application areas would in turn each be supported by advancing enabling strengths in biomaterials, bio-sensors and actuators, and bio-imaging technologies.

The priorities for bioengineering are to emphasize the establishment of the "go to" Centers of Excellence, first hub facilities and then satellite facilities, with "star" faculty to lead each Center. The enabling technologies would be enhanced progressively, following completion of the Centers of Excellence.

For **cancer research**, which is nationally a long-standing and well-funded area of bioscience research with strong competitors, the cancer research platform members decided to focus on establishing a key field of excellence and then leverage that reputation for subsequent growth.

Overall, the cancer research platform identified five key niches for Arizona to focus on over the course of the next five years:

- Gastro-intestinal cancers, particularly colon and pancreas;
- Drug discovery and development;
- Bio-imaging efforts;
- Skin cancer; and
- Neuro-oncology.

The cancer research platform placed a clear priority on advancing an integrated set of three of these five niches to enable Arizona to

gain national and international recognition in gastro-intestinal cancers, particularly colon and pancreas, in combination with drug discovery and development and imaging efforts.

The other two identified focus niches that represent significant opportunities for cancer research in Arizona are skin cancer and neuro-oncology. Skin cancer is a key cancer target for Arizona, which has the highest rate of melanoma of any state. There are emerging skin cancer research programs in Arizona, particularly focused on prevention and genomics, and a broader effort is warranted similar to the scale of the GI cancer research activities. In neuro-oncology, Arizona brings a basic neuroscience research group at University of Arizona and the clinical resources at the Barrow Neurological Institute, but faces a key gap in translational scientists who can identify and capitalize on new therapeutic approaches.

Neurosciences research is a growing area of focus across research centers in the U.S. and internationally. Inherent in neurosciences research is its diversity, being a discipline in basic biological research as well as a focus for specific disease-related research. Arizona reflects this diversity with excellence in both basic research and disease-focused research programs.

Given the complexity of the brain, it is likely that the most promising strategies for addressing neurological disorders will involve a combination of basic research understandings of brain function as well as more traditional disease-specific research efforts. Thus, the goal of the neuroscience research platform is to effectively link these often separate research domains of basic and disease-focused research.

For Arizona, the organizing theme for the diverse field of neurosciences is to focus on **neurological aging and its disorders**. Arizona features some of the world's most concentrated geriatric populations, creating both a need and a ready vehicle for testing new treatments for age-related disorders. It is envisioned that a statewide consortium of universities and non-profit biomedical research organizations in Arizona could mobilize Arizona's particular strengths and opportunities in this area, rapidly establishing the state as an international leader in the field.

Under the banner of this statewide consortium in neurological aging and its disorders, Arizona can most effectively make the link between basic and disease-related clinical research by advancing two primary program areas:

- A Program in Learning, Memory and Cognitive Disorders with a primary focus on Alzheimer's Disease; and
- A Program in Motor Systems and Movement Disorders with a primary focus on Parkinson's Disease

The value of organizing into these two broad program areas rather than into more narrow niches is the acknowledgement of the critical role of basic research in developing new treatments for neurological disorders, and the provision of a flexible mechanism to continually evolve and grow its neurosciences research both in basic research and in additional disease areas, such as autism and ALS.

Identified Areas of Enhancement for the Technology Platforms

Enhancements for the Technology Platforms are concentrated in two key areas:

- Faculty; and
- Facilities and specialized labs.

A unique aspect of the process of the Technology Platform efforts is that a set of cross-cutting needs were also identified that would augment each of the three areas of focus and bioscience development more broadly in Arizona. These cross-cutting needs are discussed more fully in the section below.

Faculty Recruitment Needs

In each of the platform areas, an aggressive program of faculty recruitment was identified with specific expertise identified.

In **bioengineering**, a need for 49 to 53 faculty recruits was identified, with an emphasis placed on enabling technology areas of biomaterials, biosensors and actuators and bio-imaging, because that is where the key gaps are found in Arizona. Also key need for "star" faculty teams to lead each of the Centers of Excellence in the application areas.

In **cancer,** faculty recruitment was seen as the major area of need to enhance the competitive position of Arizona. The cancer platform plan calls for 60 to 80 faculty recruits, particularly in basic sciences (32 to 40), but also in academic physicians (12 to 20), medicinal chemists (10 to 11) and cancer epidemiologists (6 to 9).

In **neurosciences**, faculty recruitment has two primary areas of emphasis. One is to complement the base of first-rate researchers with a select number of "stars" to shine light on Arizona's overall strengths. The other is to advance the overall pool of researchers that can translate basic research to specific disease areas. Plans call for a total of 12 new senior researchers, 24 new mid-level researchers and 24 junior faculty across the two program areas. Key areas of recruitment would include:

- For learning, memory and cognitive disorders: Alzheimer's disease genetics, brain imaging, tau pathology, amyloid B peptide metabolism, cardiovascular pathology and clinical trials research.
- For motor systems and movement disorders: cell biology, innate immune mechanisms, molecular immunology and experienced leadership in movement disorder research centers.

Among the cross-cutting faculty needs to support all of the Technology Platforms and broader bioscience research in Arizona, discussed more fully below, were:

- Biostatistics and epidemiology; and
- Biomathematics/bioinformatics.

Facility and Specialized Lab Enhancement Needs

Many of the needs for specialized laboratories and facilities are covered in the cross-cutting needs, including:

- Bio-imaging;
- Transgenic animal facilities; and
- Tissue repositories.

Each of the Technology Platforms are expected to draw upon the availability of these cross-cutting needs—so these plans are indeed highly integrated—with specific needs for the respective platform area.

In addition, there is associated with each faculty recruit the need for basic office and lab space.

In **bioengineering**, the need for "go to" facilities is the major emphasis of the enhancements for the platform plan. A system of hub facilities and satellite facilities to connect researchers from across the state is proposed. There are also dedicated facilities for bioengineering needs proposed in biomaterials and biosensors.

In **cancer**, there are more limited specific needs. Drug discovery and development requires specific facilities for mass spectrometry, high throughput screening and computer-aided drug design. GI cancer calls for specialized experimental endoscopy labs, new accelerators and dosimetry for radiation oncology and expanded GI cancer screening capabilities.

In **neurosciences**, they would be a key beneficiary of bio-imaging investments, especially animal imaging, and of transgenic animal facilities. There are specialized labs required by the neuroscience platform for expanded brain bank facilities, centralized resource for transgenic animal model development and local facilities for breeding, a cell culture core facility for in vitro validation using animal and human cells, and resources for experimental therapeutics target validation.

Of particular importance for the neurosciences platform is having ongoing, sustaining support for both program areas—Learning, Memory and Cognitive Disorders, and Motor Systems and Movement Disorders, as well as pilot research funding for translational research collaborations across institutions.

SUMMARY: SHARED THEMES ACROSS TECHNOLOGY PLATFORMS EMERGE

While each of the technology platform committees have defined a focus for development in key niche areas, requiring specialized investment needs, what stands out from the technology platform plans is the shared elements across each of the Technology Platform areas:

- **Across each of the technology platforms collaboration is viewed as a key to success.** The importance of multi-institutional collaboration was strongly embraced by each of the technology platform areas, and a set of cross-cutting technology platform infrastructure resource and collaboration mechanisms were identified. More importantly, each of the technology platforms proposed specific approaches to ensure that collaboration is the hallmark of Arizona's future success.
- **All of the research platforms see a need for investments to raise the critical mass of researchers.** For cancer and bioengineering, the need is to build more critical mass in researchers in focused niches, with a broad mix of levels from promising junior faculty to rising mid-level researchers to more nationally recognized and established senior researchers. Neuroscience differs in a highly focused effort to recruit more established faculty that can help elucidate the broader strengths in neurosciences research found in Arizona.
- **The technology platforms are able to provide a focus in pursuing the development of their areas.** The cancer research platform, which is a highly competitive and well-funded area of bioscience research nationally, has selected five key niches and set a clear priority on an

integrated set of three niches to enable Arizona to gain national and international recognition in gastro-intestinal cancers, particularly colon and pancreas, in combination with drug discovery and development and imaging efforts. Bioengineering, which is a more emerging research area, fueled by the rising opportunities of linking new biological understandings with innovations in engineering domains, also has a focused approach with three key application areas identified for Arizona including neural engineering, regenerative medicine and rehabilitation engineering. In contrast, the neuroscience research platform is a deep area of activity in Arizona spanning basic, enabling tools and disease-oriented clinical research with a multitude of opportunities across these research areas. The neurosciences research platform identified two significant niches for Arizona that build on existing disease research collaborations—Alzheimer's Disease and Parkinson's Disease—but seeks to deepen the connections between basic and clinical research as well as use these diseases as a broader platform for related areas of research focus.

- **A lack of facilities and specialized labs in biosciences across Arizona impedes the ability of the state to be competitive in specific bioscience fields**. The bioengineering research platform was perhaps the most focused on the need for specific facilities to enhance its competitiveness in its focus niche areas, but the neuroscience research platform clearly identified facility gaps and shortages as a key handicap in advancing research programs and recruiting. Even for the cancer research platform, where raising the critical mass of cancer researchers was the key priority, the ability of Arizona to attract these researchers will depend on having high quality lab space available and adequate start-up packages for basic equipment. While the state has recently committed over $400 million to new facilities, it remains unclear how and to what degree these new facilities will be connected to the platform opportunities identified in this document. This is an area for further discussion and resolution.

Section 4: Metrics for Success

The key driver behind the strategy plans for each of the Platform areas is that investment is needed to move forward. But the flip side of investment is the need and discipline of measuring return. There are many dimensions for measuring the return to investing in bioscience research activities, which go to the heart of the goals and objectives of Arizona's Bioscience Roadmap, namely:

- Generating more success in attracting bioscience research funding to Arizona;
- Leveraging the institutions and capabilities found across the state;
- Generating economic development successes in commercialization and new business formation; and
- Improving the public health of Arizona's residents.

For each of these areas of focus, we propose a number of specific measures for success.

Success in research and development

- Generation of publications
- Growth in research funding, emphasizing programs and centers not just PI grants
- Cost-benefit: Cumulative research growth versus investment
- Research productivity: Average research funding per faculty
- Translation of innovation to application: Linkage of basic innovations to implementation of therapeutics, bioengineered system or techniques

Success in collaboration

- Joint research projects, including across institutions, physician-researcher projects
- Joint research publications
- Industry support

Success in commercialization and economic development

- Generation of new IP associated with investments—disclosures, patents and licensing
- Increased venture capital investment
- New firm start-ups in Arizona
- Job/Sales impact of collaborations with Arizona firms

Success in improved public health

- Increase in clinical trials activities
- Patients treated in clinical research activities
- Improvement in treatment/incidence of specific diseases

Section 5: Financial Plan

A comprehensive funding plan aligns the projected investment funds required with expected sources of funding. At this point in development, this analysis is preliminary. It is expected that as the plans are revised a more rigorous funding plan will be developed.

In this preliminary presentation of the funding plan, we present the first five year time period, with the understanding that it is only over a longer term period that the full returns of the investments being made will be realized. What is impressive is that even within the first five years significant new income from federal grants can be achieved.

High Level Five Year Investment Estimate

Bringing together the investment plans for each of the platform technology areas, with the cross-cutting support resources, results in a high-level five year budget estimate in a range from $599.5 million to $681.5 million. The following table sets out the costs by platform area as well as funding for new positions, recruitment packages, equipment/operations, space and other collaborative support mechanisms.

Table 1
Preliminary Investment Needs by Near Term Technology Platform Areas and Cross-Cutting Enhancements

	Five Year Total	Platforms			Cross-cutting Support Resources
		Neurosciences	Cancer	Bioengineering*	
Position					
Academic Faculty	$124.9-140.1M	$34.6M	$20.8–$30.0M	$40.6–$46.6M	$28.9M
Post-Doctoral Fellow	$10.3–$12.1M	$2.1M	$1.2–$1.8M	$4.0–$5.2M	$3.0M
Graduate Student	$5.8–$7.0M	$0	$0.8–$1.2M	$2.4–$3.2M	$2.6M
Support	$77.1–$79.8M	$7.1M*	$0.5–$0.6M	$22.5–$25.1M**	$47.0M
Subtotal	$218.1–$239M	$43.8M	$23.3–$33.6M	$69.5–$80.1M	$81.5M
Recruitment	$116.1–$132M	$42.0M	$23.2–$32.8M	$32.4–$38.7M	$18.5M
Equipment/Operations	$124–$159.9M	$2.8M	$20.0–$38.0M	$64.7–$82.6M	$36.5M
Other	$44.4–$44.5M	$30.0M***	$1.4–$1.5M	$0	$13.0M****
Space	$96.9–$106.1M	$21.1M	$15.6–$20.1M	$33.9–$38.6M	$26.3M
TOTAL	$599.5–$681.5M	$139.7M	$83.5–$126.0M	$200.5–$240M	$175.8M

- Includes Central Administration investment of $4.3M

** Includes Central Administration Support of $2.7M

*** Funds for Collaborative Research, Pilot Projects, Sustaining Funding

**** Ongoing support, technology commercialization fund

Estimated Sources of Funding to Cover First Five Years of Investment

In terms of sources of funding there are many potential sources, including:

- State program funds, which would be new state appropriations. It is expected that this would involve appropriations of $10 million in year one, $20 million in year two and $40 million for years 3–5.
- State capital funds going towards new space requirements, which would be an allocation of a limited portion of the state's recent $440 million bond issuance to cover the $96.9 million to $106.1 million of space funding needs.
- New private and philanthropic contributions, expected to total approximately $40 million over the first five years, starting at $3 million in year one and growing by $3 million annually.
- Federal grants generated by new faculty hires, which is expected to be $750,000 (direct) annually per full professor, $400,000 (direct) annually per associate professor and $200,000 (direct) annually per assistant professor.
- Increased federal funding generated for existing faculty due to cross-cutting facilities and support resources. It is estimated that across the 400 to 500 faculty in Arizona an average annual increase of $50,000 in grant income will be generated, of which roughly $30,000 will be generated for salary coverage and indirect reimbursements.
- Fee for Service revenues from Core Support Facilities from state wide usage of core facilities by other research organizations are estimated at 10–20 percent of total core expenses.

Table 2
Preliminary Sources of Funding for Investments in Cross-cutting and Near Term Technology Platform Plans

Source	5 Yr Total
State Program Funds[1]	$150M
State Capital Funds[2]	$96.9–$106.1M
Direct costs from Federal Grants generated from new hires	$191.4–$210M
Increased direct federal funding for existing faculty	$60–$75M
Core Support – Fee for Service	$18–$36M
New Private/Philanthropic	$40M
Target Gap	$43.2–$64.4M
TOTAL	**$599.5–$681.5M**

Estimated Gap in Funding—and Longer Term Prospects

These sources of income generate a hefty level of funding, **but there remains a targeted gap over the five years of $43 to $64 million.**

This gap can be addressed through a combination of efforts, including generating additional sources, particularly collaborative equipment and program grants from NIH and additional fund-raising especially from key philanthropists seeking to make a contribution to public health and further refinements on timing and level of investments.

Another key source could be having institutions allocate a portion of the indirect costs from new federal funding generated by new hires. A modest allocation of approximately 25 percent of indirect costs would nearly cover the entire gap.

Another key source of potential funding is from technology commercialization and licensing income. As part of the overall Arizona Bioscience Roadmap, there is going to be a concerted effort to move technology

from the bench to the bedside and enable technology spin-offs and aggressive licensing of technology.

It is important to note that most of the ongoing costs of this initiative spanning years 6 through 10 is estimated to be largely covered through the direct generation of new federal grants. It is expected that costs for these investments, including ongoing salary costs for the nearly 200 new faculty hires, would amount to an additional $353–$398 million in the second five year period. Direct costs from federal grants generated by the new hires are estimated to reach $336–$372 million—nearly equal to the costs.

This means no significant new state investments are needed to support the major activities encompassed in the strategic plans for the three platform areas and cross-cutting enhancements in years 6 through 10.

This will enable new areas of biosciences research and development to be addressed, while having a strong foundation upon which future investments build upon.

Section 6: Next Steps

Key next steps in moving the Arizona Roadmap focus on developing the Technology Platform areas forward are detailed below.

Formation and Activities of the Arizona Biosciences Steering Committee

One crucial effort for advancing the Arizona Roadmap is the formation and activities of the Steering Committee. The Flinn Foundation has established the Arizona Biosciences Steering Committee to play several roles, including:

- Catalyze and steer private and public actions in support of Roadmap implementation;
- Educate and inform opinion leaders on Arizona's opportunities, progress, and needs in the biosciences;
- Identify progress, remaining gaps, and encouraging action; and
- Serving as steward of the Roadmap.

The importance of advancing Arizona's position and standing in the biosciences is too significant for the state to not have it be a broad community-led effort.

First Year Action Steps of the Technology Platforms

As the Arizona Biosciences Steering Committee's activities take shape over the next year, each of the Technology Platforms has identified an initial set of actions in the next year that revolve around four key activities:

- Organize Alliances
  - Set up at least informal organization with staffing support
  - Inclusive membership to build trust
- Communications
  - Hold symposia and conferences
  - Web site that can also do video conferencing
  - Technical networks
  - Hold networks every quarter and rotate around state
  - Create directory of experts/talents/work groups
- Broker Collaboration
  - Leverage near-term opportunities currently under development
  - Align and pursue opportunities to prepare multi-institutional proposals, particularly targeting NIH Roadmap and NIH broad program announcements in Platform areas
  - Identify projects highlighted by technology programs and offer incentive dollars through ACDRC
  - Promote pilot studies
- Raise Funds and Set Broad Priorities
  - Brief Congressional Delegation
  - Pursue federal and other funding opportunities

Encouraging Translational Research from "Bench" to "Bed"

A third area of focus in the next year is the question of how to link the "bench" with the "bed"—research applications to health care prevention and treatment. A number of mechanism and organizations have been established to address this, from the Arizona Biomedical Collaborative (ABC) and the Arizona Health Science Center—Phoenix, among others, but this area will require more focus and attention. Progress has been made in recent months to link these efforts, including collaboration among and between Tucson, Phoenix, their respective universities and clinical practices at a range of institutions including Banner, BNI and Mayo. Also, Flagstaff Medical Center is a key collaborator with Gore, and University Hospital has ongoing collaborations with the University of Arizona researchers. This area must continue to be a focus in platform implementation.