BIOTECHNOLOGY AND THE LIFE SCIENCES: BUILDING ON OUR STRENGTHS, SUSTAINING OUR COMPETITIVENESS

2002-2003 Report to the Governor

Council on Science
and Biotechnology Development

March 2003

The Honorable Rick Perry
Governor, State of Texas
Austin, Texas 78701

March 10, 2003

Dear Governor Perry:

On behalf of the members of the Council on Science and Biotechnology Development, may I express our sincere appreciation and gratitude for the privilege to serve you and the State of Texas. Peter Drucker said it best – "The best way to predict the future is to create it." We salute your foresight in predicting and creating the opportunity Texas has to emerge as a global leader in science and biotechnology by charging the state and this committee:

> "My vision is to create a seamless system of innovation from the laboratory to the marketplace, harnessing the brainpower of state and regional leaders to bring the inventions of our universities and scientists to the marketplace for the good of our people."

The members of the Council were ably guided by the experience and counsel of four subcommittee chairmen:

Tom Loeffler – Research Enhancement
Pike Powers – Workforce/ Talent and Skills
David Nance – Technology Transfer
Charles Tate – Capitol Formation

We acknowledge the chairmen for their diligence, hard work, insight and commitment to translate the resources of the State and the intellectual assets of the Council into a comprehensive strategic recommendation for setting Texas on a course to prevail in the competition of emerging global leaders in science and technology.

If I may take further personal privilege to offer you an idea that I believe can permit the accelerated implementation of the ideas, recommendations and strategies presented in the report.

Texas is unique among states. It boasts the biggest medical center in the world, the biggest seaport in the United States, the Space Capitol of the world and is the biggest state in the lower forty-eight. We are constantly in the mode of being the best. It is sometimes said Texas is a state of mind.

In striving to be the best, Texas has enjoyed tremendous natural resources which in large measure have been derived from its abundant resources of land – we have grazed cattle on our land to build cattle empires like the King Ranch, we have grown cotton on our land to create jobs and commerce through corporate entities like Anderson Clayton and we have pumped oil from our lands to create corporate giants such as Humble Oil and Refining (Exxon-Mobile) and Texaco.

On occasion when the project was compelling enough, we converted our land resources to needed assets. When the state needed a state capitol, we sold a portion of the XIT Ranch and converted one land asset to another.

The time has come once again to consider converting some of our assets to different tools of production. Just as the land has been the basis of our economic success in cattle, cotton, and oil, so too can the land provide a foundation for the creation of the infrastructure that will be necessary to build laboratories, incubators and institutions of higher learning and K through 12.

Our history is written from the ground up and we made our living and our fortunes from the soil. We can once again build our future on the strengths of our past. As you well know, when Texas joined the Union it was a Republic. IN the ceremonial annexation of Texas to the United States, the Republic of Texas negotiated and retained its rights to public lands, unique to the admissions of states to the Union. We have been good stewards of the land from which we have derived our livelihoods and our successes.

I ask your scholarly consideration and diligent deliberation of a proposal that would preserve the larges portion of our 20 million acres of state land for posterity while converting a reasonable and prudent portion of our most precious state asset of land into the infrastructure of the new engines of our prosperity.

Dr. Richard Smalley, Nobel Laureate in chemistry and Professor of Rice University, in service to your Council has challenged us to be bold. The seeds of the future are planted in ways we may not yet understand in nanotechnology, proteomics, informatics, human, plant and animal genomes and biosciences. Texas has the ability to lead the global paradigm shifts into the future with judicious and prudent utilization of its most precious, durable and prolific resource – land. The land that nurtured our commerce in cotton, cattle and oil may now nurture the commerce of the future in science and biotechnology. In the simplest application we can at least trade non-income producing land for land next to medical centers under biotech parks and still retain the Texas legacy of land holdings. Some might call this infrastructure. I prefer to call it Texas tradition.

Chairmen Loeffler, Tate, Nance and Powers have asked that special emphasis be given to the following additional keystones of charting our course for global competition in science and biotechnology:

- Texas must focus its energies and talents on giving added value to its natural resources, which include its people resources and their intellectual property.
- Governor Perry must adopt a plan for sustainability and provide the leadership to assure that the road map guiding Texas to becoming a global leader in science and biotechnology is followed.

- A small but reasonable portion of existing sources of existing sources of capital from significant state retirement funds investment where presently placed in funds of funds and invested in east and west coast emerging companies should be reviewed and redirected to emerging companies in Texas.
- Seed funds for expanding our competitive advantage in attracting federal grants must be enhanced by eliminating the tax on indirect reimbursement.
- Texas must utilize the leadership and resources of the Office of the Governor to attract and retain major pharmaceutical presence.

Pursuant to your charge, the following report documents over ten months of work by great minds in Texas. We have sought to provide you with data, findings, and recommendations to take us into the 21st century as a global leader in the life sciences. We have addressed three key questions: Where are we now, where do we want to be, and how do we get there? The attached report and appendices seeks to build upon Texas' strengths and your leadership.

Ashley Smith

Governor Rick Perry

The Honorable Ashley Smith, Chair
CEO, The Institute for Rehabilitation & Research

Sub-Committee Chairs:

Tom Loeffler
Research Enhancement

David Nance
Technology Transfer

Charles Tate
Capital Formation

Pike Powers
Workforce/Talent and Skills

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Dr. John D. Stobo
President, The University of Texas Medical Branch at Galveston

Acknowledgements:

The Chairman and Council acknowledge the support and contribution of the following individuals in helping make our discussions and deliberations successful –

- Diane Rath, Chairman of the Texas Workforce Commission, for a grant that provided the necessary resources to obtain the data, information, and consultancy services
- Tom Kowalski and his staff of the Texas Healthcare and Bioscience Institute for the administrative and logistical support of each council session, and for providing critical guidance on legislative impact and public-policy
- Linda Domelsmith of the Texas Higher Education Coordinating Board for her ready-supply of past and current knowledge of the State's education research programs
- Richard Seline and New Economy Strategies for their overall counsel and understanding of life science economic development, benchmarking, data analysis, and report preparation throughout the Council's work; Meg Wilson and Laura Wright for enhancing our knowledge and the final product of our report.

Through these individuals and their participation, our efforts have been strengthened and our response to the Governor has been made all the more thorough.

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Overview of the Mission of the Governor's Council on Science and Biotechnology Development

On January 26, 2002, in response to the unprecedented growth of economic opportunities within Texas' life science sectors, Governor Rick Perry formed the Governor's Council on Science and Biotechnology Development. In his charge to the Council, Governor Perry said,

> "My vision is to create a seamless system of innovation from the laboratory to the marketplace, harnessing the brainpower of state and regional leaders to bring the inventions of our universities and scientists to the marketplace for the good of our people".

The Council, chaired by Ashley Smith, CEO of The Institute for Rehabilitation and Research (TIRR), responded by recruiting Texas' best minds from its universities, healthcare institutions, legal firms, investors and other entities with expertise in the area. These outstanding men and women developed a series of recommendations to help Texas merge the research strengths of academia with entrepreneurial talent to create and cultivate a major engine of economic growth in the state.

This report offers those recommendations in response to the Governor's charge and in anticipation of the challenges facing Texas as it seeks a leadership position in the life sciences arena.

Committees

The Council developed its recommendations through four committees, each with a unique charge:

Capital Formation Committee

Charged with identifying mechanisms for securing early-stage capital for biotechnology and life science enterprises in the state, and identifying strategies to educate the investor community on the state's biotechnology and life science investment opportunities.
Chairman: Charles Tate
Committee Members: Anne Armstrong, George Bayoud, Dr. Tom Caskey, Dr. Juan M. Sanchez, Dee Kelly, Jr., Tom Kowalski, Dr. John Mendelsohn, Tom Mullins, Chancellor Arthur Smith, Dr. David Smith, Gary Woods

Research Funding Committee

Charged with identifying ways to foster collaboration among institutions and dramatically increasing the level of federal research funding flowing into the state.
Chairman: Tom Loeffler
Committee Members: Dr. Perry Adkisson, Chancellor R.D. Burck, Dr. Fransisco Cigarroa, Dr. Ralph Feigin, Dr. Ronald Garvey, Steve Gens, Chancellor Howard Graves, Dr. Mario Ramirez, Dr. Craig Rosenfeld, Dr. Jim Willerson

Technology Transfer Committee

Charged with identifying ways to enhance transfer of academic research and development to commercial applications and opportunities.
Chairman: David Nance
Committee Members: Dr. Robert Gracy, Dr. Mae Jemison, Tom Kowalski, Bruce LaBoon, Mr. Richard Seline, Dr. Richard Smalley, Ashely Smith, Dr. John D. Stobo, Dr. Kern Wildenthal, Terry Young

Committee Meetings

Thursday, April 25, 2002
San Antonio

Friday, September 13, 2002
Houston

Friday, October 25, 2002
Dallas

Workforce Committee

Charged with identifying ways to promote the establishment and expansion of educational and career preparation programs related to science and biotechnology. Its strategies were intended to address all levels of employer need, including technicians, scientists and managerial and administrative staff, and to promote workforce-training models designed to retrain workers for biotechnology-related careers.
Chairman: Pike Powers
Committee Members: Dr. Perry Adkisson, Dr. Jose Amador, Peter Felix, Steve Gens, Chancellor Alfred Hurley, Dr. Diana Natalicio, Jack Nelson, Bob Reeves, Chancellor Lamar Urbanovsky, Dr. Pam Willeford

Executive Summary

There's something about the indomitable Texas spirit that drives us to succeed. In the beginning, we forged from a wild land a thriving economy based on cattle and King Cotton. Later, we mined the earth and built an entire industry based on oil and gas.

As the space race began, we took our first bold foray into the technology sector and became a leader in space exploration, spinning off resulting technologies. As modern healthcare developed, we created one of the world's most prestigious medical centers. And as our economy changed to one based on information, we developed new skills in information technology.

Now we have the opportunity to leverage our expertise in the biological and technological sciences to become a leader in what many consider the most life-changing era of the world: the Age of Biotechnology.

Among the many recommendations offered within this report, several are particularly crucial — and must be given priority if this initiative is to catapult Texas to the forefront of the biotechnology and life science industry. Simply, for Texas to be a global leader in the life sciences we must:

Create a sustainable mechanism to lead the effort:

- Create a statewide entity, initially within the Governor's office, to advocate and facilitate technology development in Texas.
- Create continuity and leadership for Texas science and biotechnology development.

  Texas must create a stable vehicle to market and promote its life science assets, ease commercialization, connect regional capabilities, coordinate federal funding strategies and provide the tools needed to facilitate the overall process. Historically, Texas' balkanized governmental structure has hampered its ability to pursue consistent, long-term economic development strategies. Establishment of a sustainable mechanism, such as an executive agency, would allow Texas to coordinate the state's initiatives with regional strategies and assets, improving the overall effort.

Fill the research-to-market gap:

- The Governor and the Legislature should use their authority to increase the availability of in-state pre-seed/seed/development-stage venture capital targeted for investment in intellectual property for both human health and agriculture.

  Texas must unlock the investment potential of its vast pension and investment funds through a fiscally sound strategy that supports innovation and wealth creation through biotechnology development.

Develop collaborative regional tactics:

- Develop new regional "Centers of Life Science Excellence" in basic and interdisciplinary research to leverage regional assets, fill scientific and monetary gaps and encourage greater collaboration among companies, institutions and scientists.

Regional collaborative tactics would allow Texas to exploit the full potential of its widespread and diverse assets to produce a whole more valuable than its parts.

Develop a statewide federal funding strategy:

- Increase Texas' share of the federal funding 'pie', broadening the range of scientific excellence that can be supported, resulting in Texas' heightened competitiveness.

  A federal funding strategy is an essential to ensuring immediate funding for university and industry research efforts and better leveraging the state's current funding streams.

Improve education and skills development for the life sciences

- Develop strategies to improve K-12 life-science related education.

- Develop community and technical college programs to provide an educated workforce for the biotechnology industry.

- Develop strategies to ensure Texas has the workers, research scientists and faculty, and lab space to support industry development.

Texas must make an immediate and sustained commitment to improving science and math education and its ability to recruit educate and retain scientific and managerial talent.

Identify Targets of Opportunity

- Nanotechnology
- Vaccines
- Molecular Sciences
- Advanced Materials and
- Manufacturing
- Animal and Plant Modeling
- Wireless Information Technology/Software Applications

Texas possesses tremendous strength in key biotechnology niches. Our healthcare delivery base, as exemplified by the Houston Medical Center, represents a world-renowned asset 50 years in the making. And the outstanding research occurring at Southwest Medical Center is the result of 15 years of persistent attention and creative investment. Using such successes as our launch pads, Texas can do more than remain competitive. We have the opportunity to leapfrog our national and international life science competitors and become the global leader in many of the sciences that will shape the century before us.

But before we can realize this goal, we must lay the groundwork. The Council's key recommendations constitute the foundations for more specific and far-reaching recommendations.

Texas must have a sustaining mechanism that state leaders, both public and private sector, can look to when coordinating strategies, new legislation and new resources.

We must be able to inventory our assets, nurture our entrepreneurial spirit and convey the urgency of our mission to legislators, state agency chairmen and business and community leaders. To do this, Texas must have a sustaining mechanism that state and private sector leaders can look to when coordinating strategies, new legislation and new resources. And Texas leaders must commit — TODAY — to thinking creatively and acting aggressively to meet the challenges of creating a fully competitive research-to-market system for Texas bioscience and biotechnology.

Texas comes to the global competitive race with many significant advantages and opportunities on which to leverage. However, connecting the 'dots' – the institutions, individuals, industry interests, and investment sources requires specific attention and focus by a broad-base set of stakeholders. These strengths will not remain unchallenged from other U.S. states and international regions; the Governor has recognized this level of competition and our strengths on which to meet the challenge.

Why the Life Sciences are Important to Texas?

While the Governor's charge to the Council has been to identify a seamless process from 'bench to bedside to market', the root of the life sciences is in the search for new discoveries that will increase quality of life as well as diminish the effects of major diseases. Exhibit 1 lists the major causes of death to Texans and thus reminds us of the very reason we continue to invest in our research and medical institutions, our world-class patient care, and why we must now strength our opportunities to commercialize ideas that will be the break-through for us and future generations of Texans. With a fast-growing portion of older citizens throughout Texas and the U.S, the amount of discretionary dollars to be spent on maintaining good health and fighting diseases of aging will only be increasing the burdens on health care costs and institutions. Therefore, the linkages between patient care, innovation, discovery, commercialization, and quality of life has been well established. Texas must strengthen these linkages among health care providers, state and local agencies, researchers, entrepreneurs and innovators.

Exhibit 1

Rank	Cause	Number	Rate	Percent
1	**Disease of the Heart**	**42,968**	**211.2**	**28.7**
2	**Malignant Neoplasms**	**33,298**	**163.7**	**22.2**
3	**Cerebrovascular Diseases**	**10,721**	**52.7**	**7.2**
4	**Accidents**	**7,602**	**37.4**	**5.1**
5	**Chronic Lower Respiratory Diseases**	**7,284**	**35.8**	**4.9**
6	**Diabetes Mellitus**	**5,195**	**25.5**	**3.5**
7	**Pneumonia and Influenza**	**3,708**	**18.2**	**2.5**
8	**Alzheimers Disease**	**3,171**	**15.6**	**2.1**
9	**Intentional Self-Harm (Suicide)**	**2,093**	**10.3**	**1.4**
10	**Chronic Liver Disease and Cirrhosis**	**2,092**	**10.3**	**1.4**
	All Other Causes	**31,631**	**155.5**	**21.1**

Understanding Biotechnology: A Snapshot of the Sector

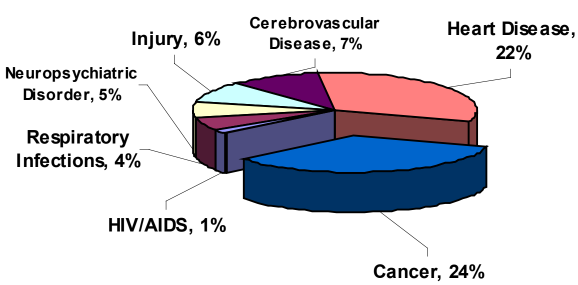
Life Science Drivers

As the baby boomer generation continues to age, the emphasis placed on healthcare and its various facets continues to grow. Developments in research labs across the world have allowed the population to enjoy increasingly longer life expectancies. Despite these breakthroughs, the cure for many life-threatening diseases remains elusive (see Exhibit 2) and the cost of healthcare continues to rise at an alarming rate.

Exhibit 2[1]

The Americas - Causes of Death

Percent of Total Deaths, 2000



A study conducted by the Milken Institute revealed that over 50% of deaths in the United States were attributable to heart disease and cancer in 2000. Treatments and medical expenses associated with these illnesses are astronomical. For instance, a one percent reduction in mortality from cancer would have an economic value of $500 billion.

[1] Note that the remaining causes of death are attributable to hundreds of other diseases, viruses, etc. that each represents less than 1%, but when aggregated total 30%.

Exhibit 3

Economic Value of Reducing Deaths

Disease	Total Savings (US$ Trillions)
Heart	48.3
Cancer	46.5
Digestive Organs	9.6
Breast	4.6
Genital and Urinary	4.1
Stroke	7.6
AIDS	7.5
Circulatory Disease	5.7
Flu	3.4

Kevin Murphy and Robert Topel
University of Chicago

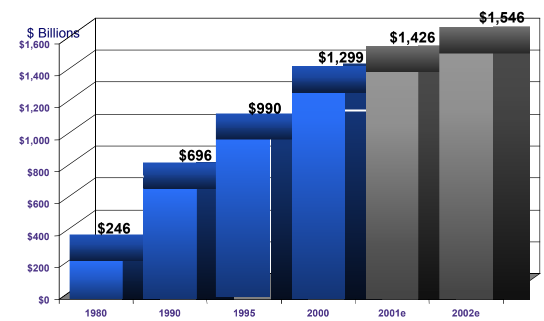
However, solutions emerging through biotechnological developments and discoveries can help to reduce these costs, increase productivity and enhance overall patient care. Savings – in the trillions – could be realized with the production of life saving treatments and drugs to both prevent and cure diseases such as heart disease (see Exhibit 3).

As technology and innovation continue to drive developments and change paradigms across all aspects of our lives, so too does it result in a shift in the healthcare industry's approach to preventative treatment of these diseases. Using biotechnology, researchers are attempting to use genetic therapy and other revolutionary treatments to combat these omnipresent diseases. Significant attention and dollars are devoted to bio-related research, which represents a huge opportunity for regions with the critical mass to support a thriving life sciences cluster.

Federal and state policy-makers are constantly scrutinizing the increasing cost of healthcare (see Exhibit 4) from hospital administration to prescription drugs. On one hand, health care delivery has historically relied on superior facilities, high staff to patient ratios, and comprehensive packages of programs and services. The pressure to lower costs exerted by HMOs, insurance providers, and state agencies pit these types of delivery offerings against the expectations that Americans have for patient care.

Exhibit 4

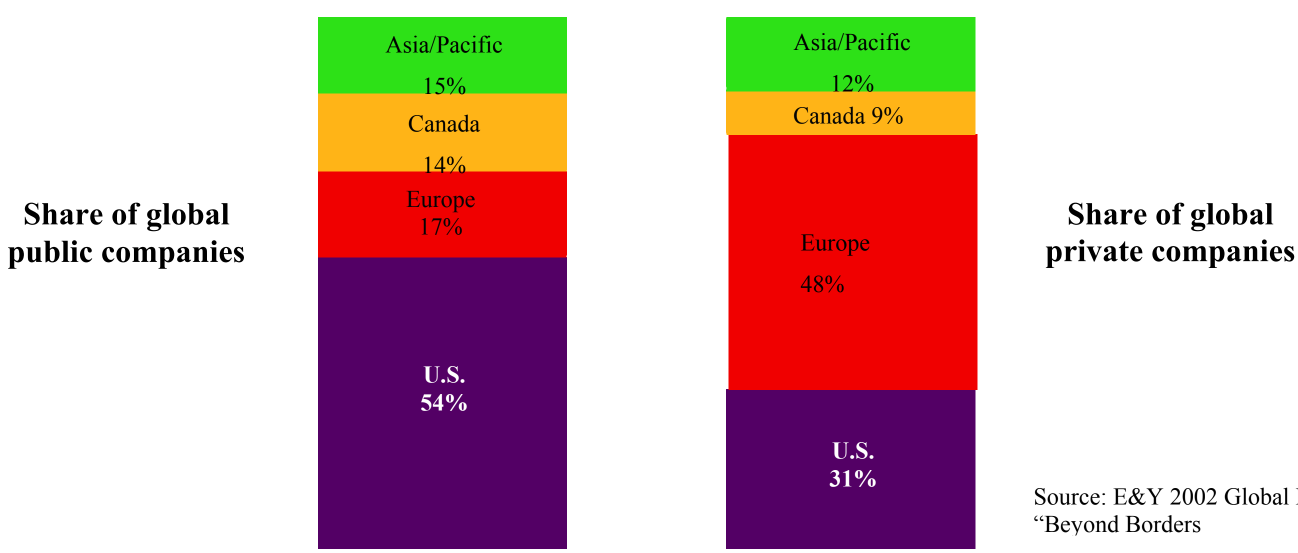
US healthcare spending continues to grow



Source: Center for Medicare and Medicaid Services (HCFA), 2002

At the same time, the advancements in genetic discoveries and new drug compounds increase the likelihood of more tailored medicines and pharmaceuticals. The pathways for diagnostics, therapeutics, and other methods of identifying and relating individualized approaches for smaller patient groups will be more the norm in the future.

Exhibit 5



Source: E&Y 2002 Global Report – "Beyond Borders

The Competitive Landscape: Global and Domestic

Global see

Some 40 regions in the US and approximately 17 globally are racing to develop the next generation of life sciences clusters. From Singapore to Australia in the Asian Pacific; from Saskatoon to Toronto in Canada, from Cambridge to Greater London to Scotland to Ireland in Great Britain; from Basil Switzerland to Paris in Europe – global competitors are emerging in specific life science arenas. With more than $3 billion in new international resources being amassed for life science development, Texas cannot afford to view its challenge in merely a domestic context.

Formation of a statewide strategy must take into account the realities of a global marketplace – research and development generally occurs in several countries before reaching the marketplace Ireland and Scotland alone are home to more than 50 major pharmaceutical outsourcing facilities, while Mexico has over 100 production and manufacturing facilities. Nearly all of the U.S.' largest companies have facilities distributed throughout the world and do most of the production outside of the country.

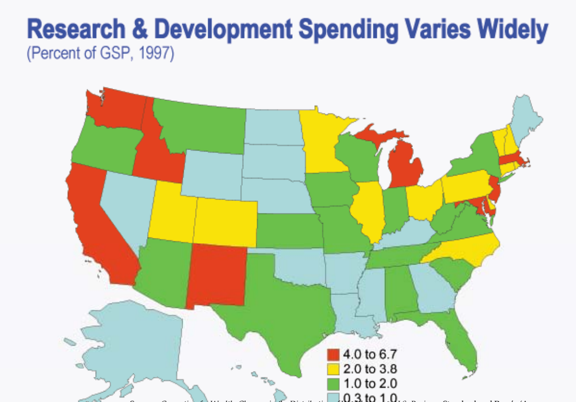
Formation of strategies that seek to attract, recruit, market, and promote Texas' life sciences require this global perspective – even through the U.S. is still the dominant driver of biotechnology, the Asian 'tigers' of China, Korea, Taiwan, and Singapore are poised to leapfrog this competitive position within the next eight to 10 years.

Domestic

Throughout the U.S., cities, states and regions are examining their resources and developing strategies to compete for global leadership in the biotechnology sector (Exhibit 6). In a 2001 survey of 77 local and 36 state economic development agencies, 83 percent listed biotechnology as one of their top two targets for industrial development.[2] At present, 40 domestic and 17 international regions are amassing the talent, infrastructure and capabilities necessary to become a dominant player (Exhibit 7).

Driving this trend are huge potential economic and societal benefits. Between 1995 and the second quarter of 2001, venture capitalists made 1,109 separate investments totaling $10.1 billion in American biopharmaceutical firms.[3]

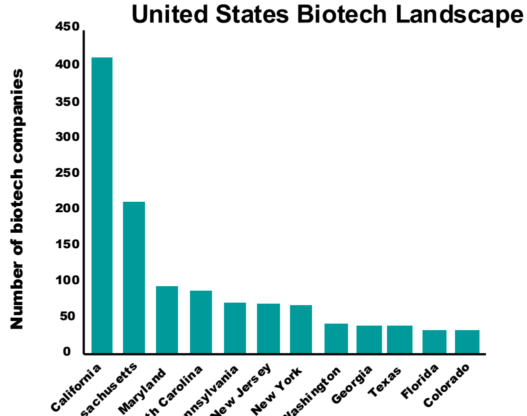
Exhibit 6



Source: *Competing for Wealth: Changes in the Distribution of Wealth Among U.S. Regions.* Standard and Poor's (A Division of the McGraw-Hill Companies, Inc.)

In 2001, venture capitalists invested more than $300 million in Texas life sciences (Exhibit 8 on page 9).

Exhibit 7



Source: Source: E&Y 2002 Global Report – "Beyond Borders

While the economic downturn has slowed investment in most industries, the enormous strides being made in biotechnology and the life sciences, such as the recent unveiling of a preventative treatment for cervical cancer, are commanding the world's attention. In response, healthcare professionals and patients are clamoring to bring new medical miracles to the marketplace — and Texas is in a unique position to take advantage of this life science revolution.

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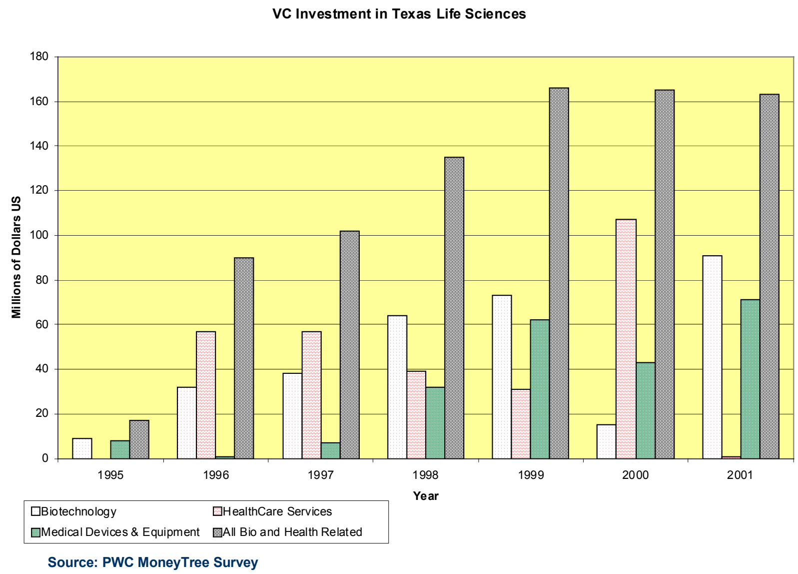
2 Grudkova 2001
3 PriceWaterhouseCoopers, 2001

Exhibit 8



In the U.S., the formation of life science clusters is considered a mandatory strategy of regional economic development. Although 40 regions are working to leverage their healthcare and research capabilities, Texas has certain advantages over these competitors. For instance, our nearly 50 years of infrastructure investment in Houston and Dallas provide the foundation for immediate development of specialty research and technology commercialization opportunities. While other regions are forced to invest in basic patient care and research facilities, Texas can invest in infrastructure that catapults its strengths.

Competitor regions appear to be gaining on Texas in three categories. First, the use of tobacco settlement funds and state appropriations for centers of research excellence and commercialization is paying off for Pennsylvania, New York, California, and Michigan. In a sense, these states have invested in growing new firms from prior research – leading to recognition and attraction of the next generation of life science research minds and entrepreneurs.

Second is formation of vital funding pools for both the acquisition of research teams and the investment in early stage startups. The use of state employee pension funds, such as CALPERS in California, and the formation of pre-seed funds such as in Georgia, are providing capital that is then leveraged with private sector resources and managed by those with serial life science expertise.

Third, Texas must compete with states that have determined collaboration is critical among multiple research institutions and organizations. Whether the Georgia Research Alliance or the Indiana Science and Technology Fund, many legislatures are benefiting by leveraging the state monies with federal, industry and philanthropic resources.

One additional observation about the national competitive landscape: many states have instituted public policies that enhance the environment for growing their clusters. For instance, the New Jersey strategy that allows emerging, growth companies to sell their early losses to more established firms – thereby creating a new pool of investment dollars in exchange for favorable consequences against state income taxes. These so-called ‘carry-forward losses’ have increased the number of startups in the New Jersey region.

Other state policies include incentives for the relocation of outsourced divisions from global life science companies, investment in life-science related infrastructure that hosts newly commercialized university research, and the recruitment of highly-regarded research teams. Simply, if Texas is to compete in the emerging bioeconomy, it must develop a portfolio approach to its strategies and tactics.

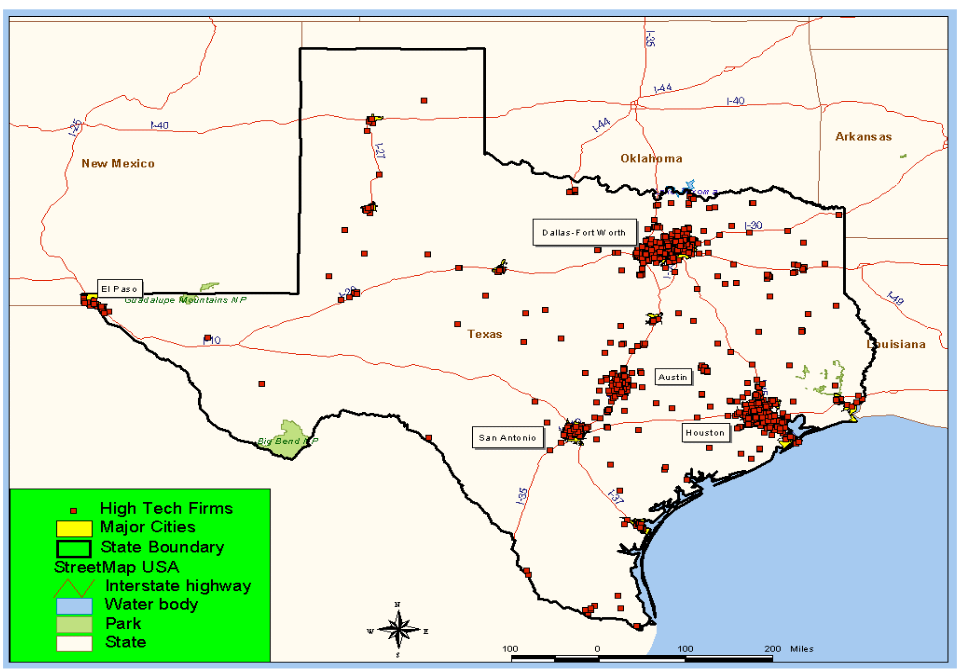
Texas Strengths to Compete

Texas truly is a state of regions – which for the past fifty years have often competed rather than collaborated with each other. This intra-state competitiveness has minimized our ability to leverage knowledge, talent, and research discovery and investment resources.

While each region has distinct assets and characteristics – and must find ways to organize within its own geographic area – the Council now recognizes that collaboration must occur from region to region. If Texas is to compete globally, it must collaborate on a statewide and local basis.

A certain way to achieve such collaboration is to first and foremost create a mechanism that “connects the dots” on the map in Exhibit 9. By linking and leveraging assets, institutions, and individuals on a daily basis, Texas can become a global leader in the life sciences.

Exhibit 9



After 50 years of investment in its healthcare facilities, infrastructure, research and educational resources, Texas' life science sector employs nearly 49,000 people. It receives 65 percent of the $2 billion spent each year on research and development in Texas' public and private institutions.

This investment has paid off handsomely. Today, Texas is a world leader in research and treatment related to cancer, heart disease, diabetes and age-related conditions. And Texas' expertise in allergy and infectious diseases has created new opportunities in national defense against bioterrorism. Texas is the second-largest technology state in the country, with assets stretching from NASA's facilities on the Gulf Coast to the Dallas-Fort Worth Telecom Corridor to Austin's Silicon Prairie. Texas is home base to some of the largest technology companies in the world.

Texas is also a world leader in agriculture. The Texas Agricultural Experiment Station is the second largest such unit in the nation. The Texas Veterinary Medical Diagnostic Laboratory is the world's largest veterinary diagnostic lab.
Texas A&M's agricultural program is an international leader in genetics engineering. Its specialists have produced the world's largest set of gene-mapping resources for beef cattle and the world's first genetic maps of bovine sex chromosomes.

Texas' wealth of knowledge and talent amply position it to lead the development of new, converging sciences such as nanotechnology, biopharming and bioinformatics. Texas, as a whole, possesses several of the key ingredients for a successful biotech economy:

- $500 million in annual NIH funding for 10 years
- $380 million or more in new venture capital during the past six years
- Several of the nation's top 20 medical research universities

But if we are to capitalize on our advantages, we must recognize that isolated regional strengths alone will not produce the economic vitality needed to propel our state into a leadership position. We must learn how to link our regional strengths into an integrated system that translates ideas into marketable products. We must eliminate the barriers present in the cycle from idea generation to product development and marketing. We must improve and increase funding for our public and private universities, medical centers and life science corporations. And we must commit ourselves to creating a highly educated workforce capable of initiating discovery, translating those discoveries into practical applications and managing complex corporate structures and new business paradigms.

And perhaps most important, we must develop a mechanism capable of providing direction, monitoring our progress and sustaining our momentum in the years ahead. This report seeks to outline the strategies, resources and tactics needed to ensure Texas' competitiveness in the life sciences. But we must remember that the state faces stiff competition and many hurdles in its path. Every aspect of our society can help — elected and legislative officials, academic and research institutions, industry CEOs and entrepreneurs, investors, regional leaders and economic development and private citizens. Our public and private policymakers must be prepared for a long and grueling race if we are to take our place in the leadership circle.

I. Where are we now?

Council Data Collection, Analysis and Findings

The committee chairmen determined at the outset that it must have the most current and up-to-date data on Texas' life science industry and capacity for increasing results of commercialization and development. While the Texas Healthcare and Bioscience Institute – a statewide organization of academic, industry, and economic development and public sector interests – had developed its annual Cluster Index reports and 21st Century Life Science Road Map – the Council required additional information on many critical elements. Though the National Science Foundation's various reports could provide the basis of national trends and benchmarking, New Economy Strategies of Washington DC was retained to gather and organize additional sources of data that would assist the Research Committee and the general Council's request.

> "The RAND, RaDiUS data sets detail where specific research is happening in our region – it is the most detailed information that we found to hunt out where federal dollars are really going and what federal agencies are actually playing a role in our region. And it also gave us an indication of significant gaps or opportunities. For instance we found out that there is just as much plant science research going on in our region as compared to the region we all thought was receiving the majority of those funds. If your region is not getting down to the baseline of your research funding distributions you just do not know what is actually happening or could happen."
> - Dr. Mary Walshok, UCSD CONNECT

One source of the data found throughout the Council report is derived from the RAND RADIUS data set. Also several informal surveys were conducted by the Technology Transfer Committee that provide insight to the perceptions and values placed on Texas' current capacities in the process of commercializing ideas into the marketplace. Finally, through the assistance and counsel of Linda Dommelsmith of the Higher Education Coordinating Board, a breadth of information collected on academic and research institutions throughout the State has been provided to compliment the emerging story on Texas' competitiveness.

The full RADIUS Analysis is available as an amendment to the final report. Through the development and assistance of Dr. Mary Walshok of the University of California San Diego's CONNECT program, and with the counsel of Ms. Donna Fossum of The RAND Corporation's Washington D.C. office, the Council has received the most complete analysis of federal funding for Texas research and academic institutions. However, most importantly the RADIUS analysis includes information on private university and industry research. While the Council has had this information at its call, the usefulness for further discussion and application can be found in the questions raised by the RADIUS analysis –

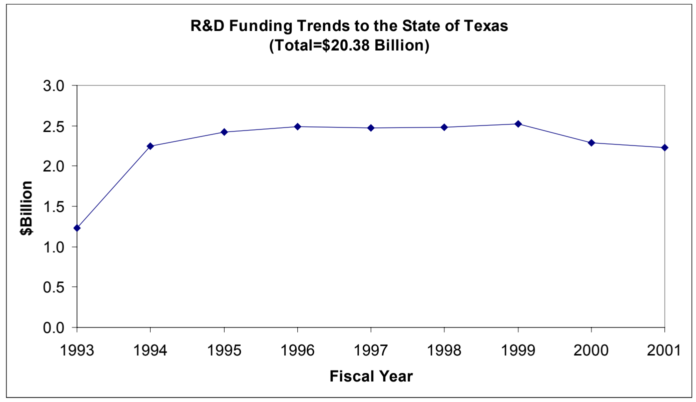
demanding on-going collection, debate and distribution.

One vital recommendation created by the Council's work and data collection is clear: Texas must find a mechanism that not only sustains the efforts of the Governor's charge but also continuously collects, analyzes, monitors and distributes data for public policy and industry strategic planning purposes.

Although constant for nearly seven years, the Council expressed a significant interest in doubling federal funding of Texas research over the next five years. To set that strategy in motion, the following data points provide important background. See Exhibit 10 for a graphic depiction of the current funding trends for Texas.

Exhibit 10

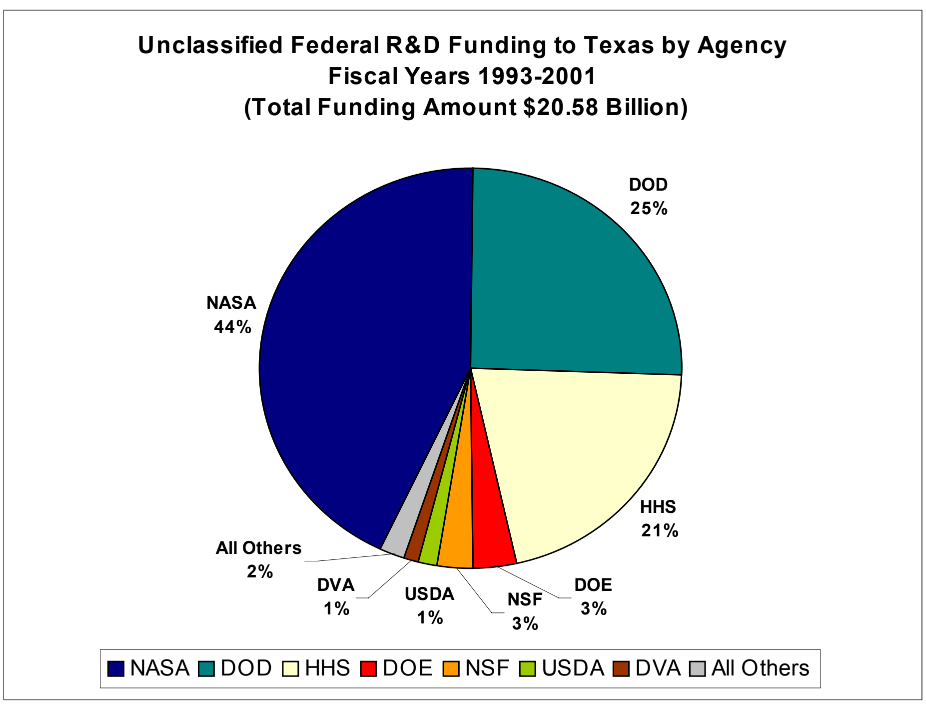
Federal Funding Trends for Texas



Source: UCSD/RAND RaDiUS (Walshok, Lee)

- From 1993-2001, Texas received $20.5 billion in research from 17 federal agencies (Exhibit 11). Such funding places Texas fourth in the nation in total receipt of federal research grant and contract dollars.

Exhibit 11



Source: UCSD/RAND RaDiUS (Walshok, Lee)

- In that same time period, Texas received $4.2 billion from HHS (90+% from NIH). California and Massachusetts grew proportionally to the annual increases in NIH funding – approximately 12% annually. Texas appears to have only grown approximately 5% - a non-competitive amount (See Exhibit 12 and 13 for HHS trend line and allocation, respectively).
- NSF funding to Texas in the same time period was only 3% of total federal funding in the State and increased approximately 5-6% annually – while California and Massachusetts had baselines of 10-11% with appropriate annual increases to maintain that level of funding (See Exhibit 12 for NSF trend line.)

Exhibit 12

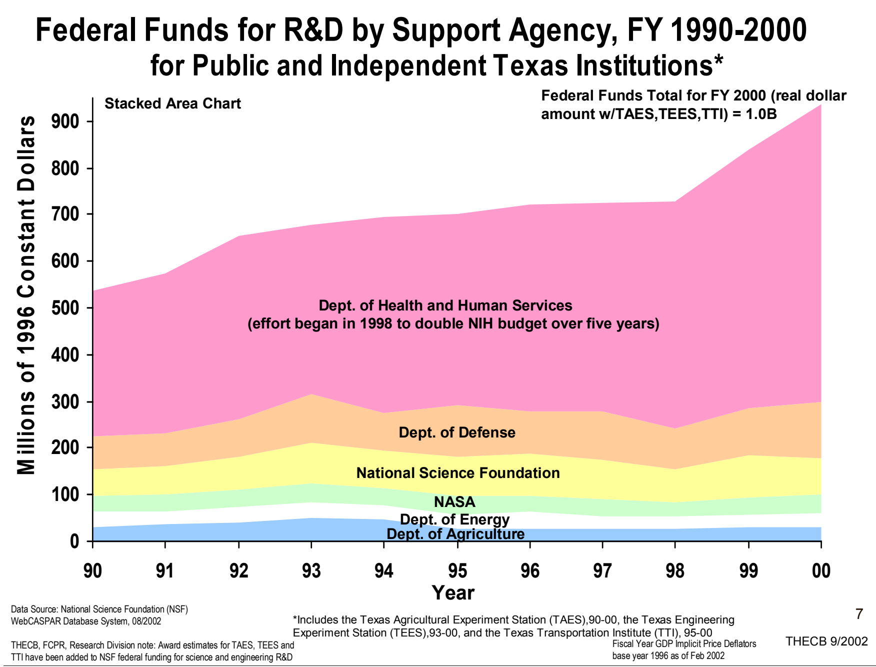
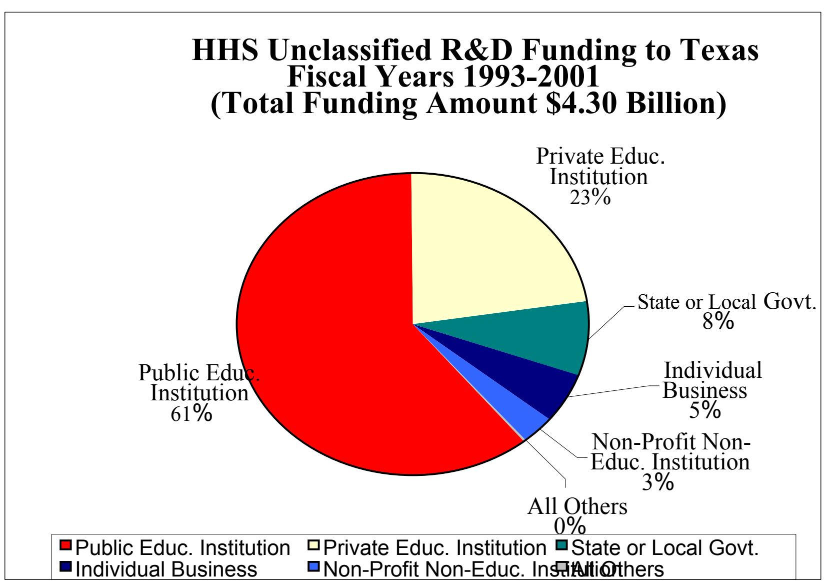


Exhibit 13

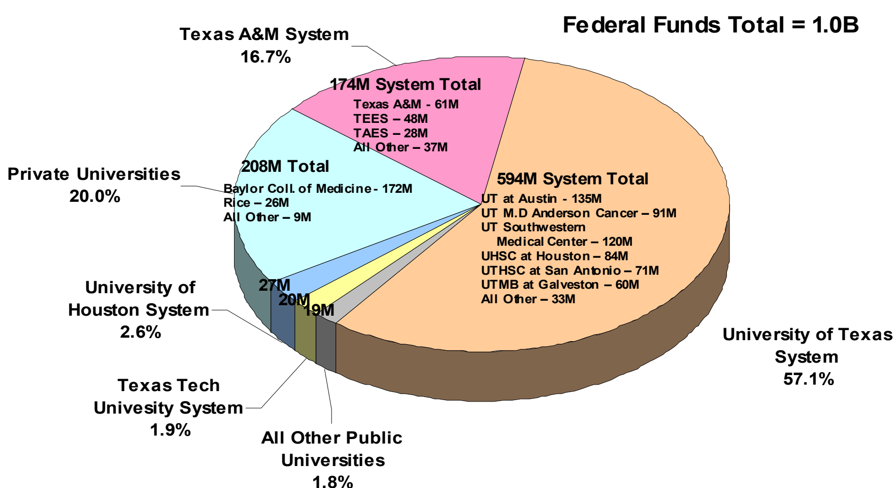


Source: UCSD/RAND RaDiUS (Walshok, Lee)

Of the $20.5 billion in federal funds, some 67% of all funds flow to the private sector and less than 23% to academic institutions and state/local government (see Exhibit 14 for allocation of federal funds).

- Some of Texas' largest federal research recipients are not institutions of higher education but private sector industry such as Boeing, Lockheed Martin, Texas Instruments, and IBM. Though over 70% of life science funding goes to the State's research and medical institutions, this funding base from all other areas of federal research that accrues to the private sector signals unique opportunities for leveraging and partnering.

Exhibit 14 **Federal Funds for R&D by System, FY 2000 for Public and Independent Texas Institutions*/Systems**



Data Source: National Science Foundation (NSF) WebCASPARDatabase System, 08/2002

10

THECB,FCPR, Research Division note: Award estimates for TAES, TEES and TTI have been added to NSF federal funding for science and engineering R&D

*Includes the Texas Agricultural Experiment Station (TAES), the Texas Engineering Experiment Station (TEES) and the Texas Transportation Institute (TTI)

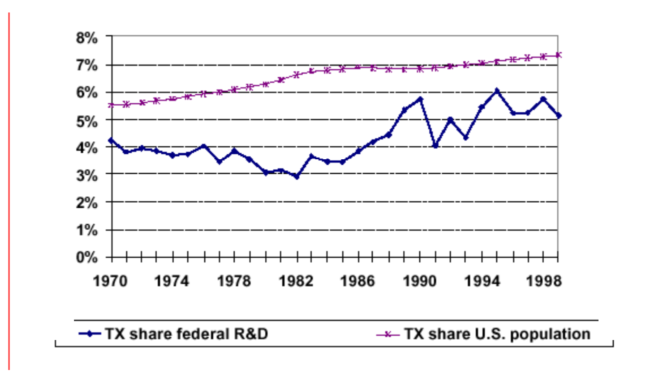
THECB 9/2002

- On a per capita basis, Texas still receives an amount of federal funding lower than its payments to the federal treasury – and this gap will only continue to rise as the State grows (See Exhibit 15).

- In certain key areas of basic science, it would appear that Texas' receipt of $180 million in federal funding for genomic research is not at a satisfactory level to compete with the science being developed in other states.

Exhibit 15 **Texas Share of Federal R&D**

FY 1970 - 1999



Source: AAAS, NSF, Federal Funds for Research and Development Historical Tables

Such a low amount in federally funded genomic research would not place the state in the rankings of the national competitors.

- Harris County is the single largest recipient of federal funding – 55% - and within that amount 44% is derived from NASA alone. However, Dallas, Bexar, Travis, Tarrant round out the significant distribution of federal funding in Texas.

Implications from the findings – questions raised

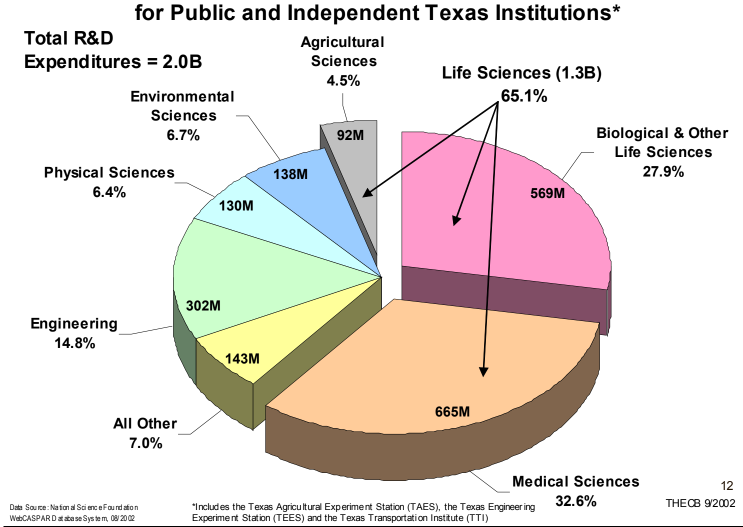
Because federal funding has not increased in proportion to other competitor states such as California and Massachusetts, several questions emerge that should drive a new strategy for the state:

1. What does Texas want for a balanced portfolio of federal agency funding?

2. What basic sciences will need federal assistance to develop that portfolio?
3. What existing or emerging areas will need additional resources for Texas to become competitive?

4. If Texas can increase its flow of federal funding, does it have the state and local support and existing regional capacities to convert research and increase our competitiveness? For instance, do we have what we need to sustain momentum in key scientific research areas while going after the promising and emerging areas of the future?

Exhibit 16 R&D Expenditures by Discipline, FY 2000 for Public and Independent Texas Institutions*



Other regions have found that dollars alone cannot build a thriving, self-sustaining industry. We must couple deep research in basic sciences with the collaborating engines of applied science and innovative thought — to create a dynamic science-based economy (see Exhibit 16 for current allocation of research dollars).

Thus it would appear the concept of Centers of Excellence in Basic and Applied Research is critical to Texas' ability to leverage assets and fill gaps.

Implications from the findings – The private sector advantage

With nearly 70 percent of federal funds flow to private sector sources (the opposite of front runners such as San Diego where 61 percent flows to research institutions), Texas possesses an advantage that may not have been exploited to its fullest.

Private sector research tends to be 'mission-oriented,' that is, the contract defines the problem and the contractor works to solve the problem. As such, it is driven to produce near-term solutions so it can take ready advantage of market opportunities.

Heretofore Texas has not fully explored how best to use our private sector strengths to advance life-science discovery here at home. For instance, Schlumberger's smart-card design research could be applied to the manipulation of laboratory data. Similarly, the wireless technologies and capacities of North Texas would be appropriately linked to research and administrative roles throughout Texas' healthcare sectors.

How can Texas institutionalize these links? One solution may be the creation of Collaborative Institutes of Applied Research and Commercialization, which several other states are using to bridge expertise, experience, and resources between biomedical and traditional industries.

Better understanding where the federal funds flow

Initial findings suggest that Texas medical schools receive the majority of federal life science research funding. In terms of the clinical research funded, this is considered applied science as it seeks to connect the 'bed to the bench.' On the other hand, a limited review of the fund-flow into basic sciences of biology, chemistry, and other areas shows less ending up in those quarters. Yet an initial review of HHS/NIH, NSF, DOD life science funding tells us that it is not a matter of whether funds should flow to the medical schools OR the higher education institutions. Texas should seek a balanced portfolio with ever increasing dollars for both arenas, for the future of biotechnology and the life sciences is calling for greater convergence — multi-disciplinary approaches which will rely on traditional disciplines coupling with emerging technologies.

Our findings suggest that in an ever-increasing flow of federal funds, Texas needs to shore up its basic research in the higher education arenas, but neither by taking funds away from the medical schools nor using negative funding formulas. We currently do not know where all the federal funding lands in all the institutions, but on a cursory level, it appears that a more strategic approach to research funding would ensure more promise from Texas R&D.

Building the capacity for innovation– from expertise to infrastructure to workforce issues

Through our comparative analysis of competitor states and regions – Seattle, North Carolina and San Diego, for instance, are doing a better job in connecting their capacities in research to their capacities in applied commercialization. This link is what has propelled them forward. It is not the silos of research but the merging of science and technology that will drive the future of the Texas economy. That's why it's critical for us to understand what gaps will stand in the way of our ability to compete.

As research appears to have clustered around a few capacities, Texas must now decide which areas of expertise to build on and where gaps in that expertise must be filled. It must also decide which areas hold little promise for development and should be abandoned. This decision should be based on where the federal funding originates and what infrastructure exists to support the discovery-to-innovation process. Whether working independently or in collaboration, regions will need to develop research specialties to meet niche opportunities. These specialties will drive critical mass.

In Texas, critical mass in the elements required to compete in science and technology has not been reached as it has in Seattle, San Diego and Boston — much less in Britain, Canada, France and Germany. Texas will need to increase its stable of talent if it wants to compete.

We will need more post-docs, more engineers and more technicians. But just as important, we will need leadership talent — men and women who understand how to build science-based industry and how to manage it effectively.

In developing this talent, Texas colleges and universities will need to emphasize the coursework that prepares them to work in for-profit as well as academic settings. They will also need to stress the value of interdisciplinary skills as sciences converge.

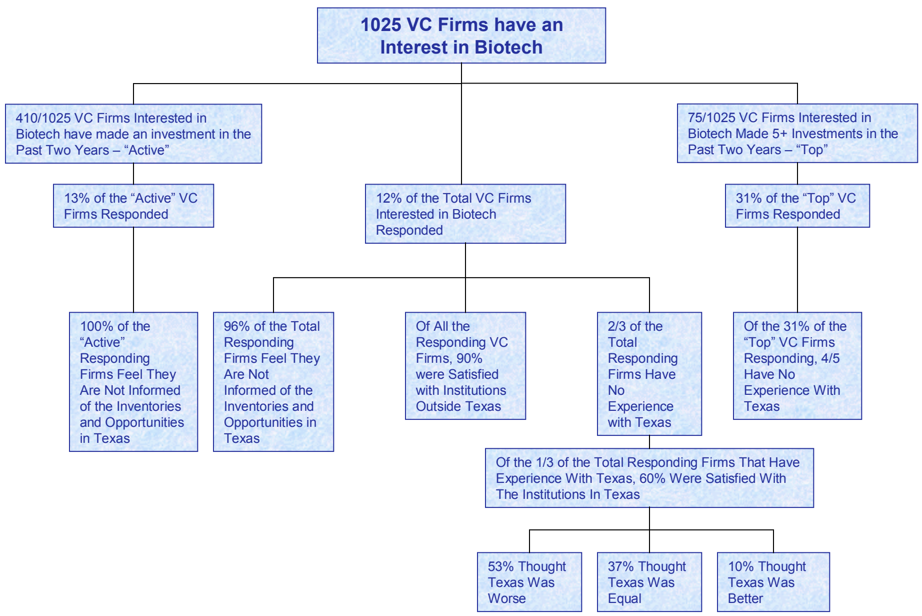
<u>By establishing R&D Funding Competitions, Texas can both foster talent development and collaborations that seek to commercialize research. These competitions would work in tandem with the Texas' highly successful $60 million Advanced Technology Program/Advanced Research Program funding, but would place a greater emphasis on investing in collaborative research and commercialization teams within and among our five to seven Targets of Opportunity.</u>

Special Emphasis on Capital and Commercialization Links

Of critical importance to the Council discussions is the linkage between capital formation and increased life science commercialization activities. Identified as a significant gap in the process of advancing the State's capacity to launch new companies, capital formation at the earliest stages of discovery and development is required if Texas is to grow and sustain a generation of life science firms. Yet, capital is required at every stage of the process of moving an idea along the path from technology transfer to technology commercialization.

Exhibit 17

VENTURE CAPITAL INVESTORS SURVEY RESULTS

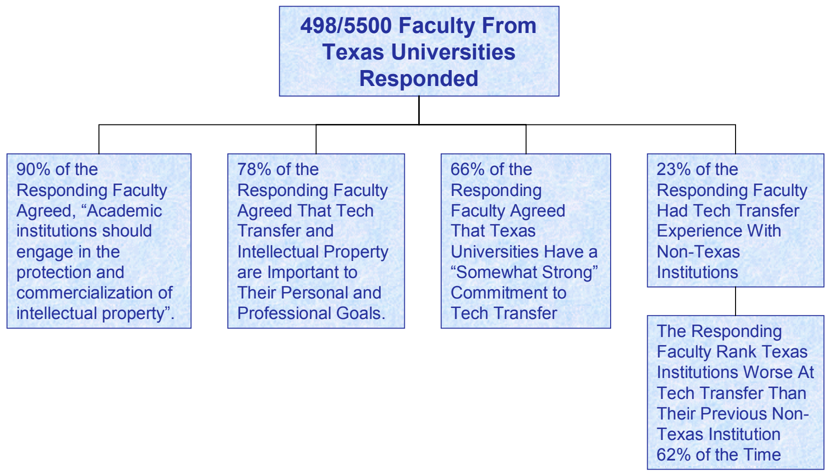


Although conducted with significant budget and time constraints, the Council was able to obtain anecdotal knowledge and perspective from various internal and external sources about Texas' commercialization challenges. The results of an informal survey among venture capital firms across the U.S., and with Texas-based faculty, technology transfer offices, and other commercialization interests, has provided some important insights as to perceived strengths and gaps (see Exhibits 17, 18 & 19 for results). While further discussions must occur with these constituencies to gain more robust data and commentary, these preliminary findings signal that greater communications is demanded with and among these vital groups.

These informal surveys also indicate that angel and venture capital are not the only potential resources available to Texas life science firms; given the nature of a highly expensive process of commercialization and development, a variety of sources and types of funding are necessary at different stages and junctures for increasing the sustainable work it takes to position a product into the competitive life science marketplace.

Exhibit 18

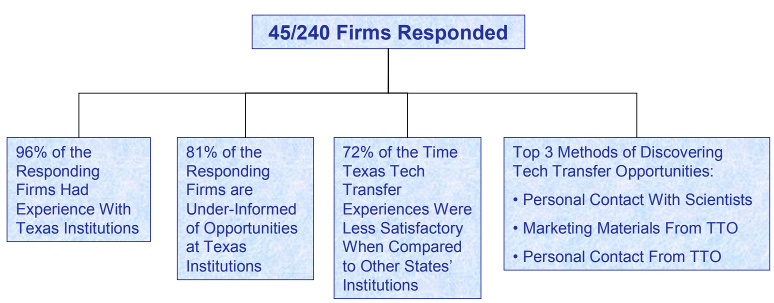
FACULTY SURVEY



While Texas has received an increasing amount of venture capital over the years, those sources alone are not enough to ensure our competitiveness. For instance, the State does poorly in seeking Small Business Innovation Research grants – federally funded proof of concept dollars that assist in moving an idea from its earliest stages of commercialization to near-market product development. While California and Massachusetts have successfully garnered the lion-share of federal SBIR dollars, states such as Michigan and Pennsylvania are encouraging and leveraging public and private investments side-by-side with applications for SBIR grants. Simply put, Texas is leaving vital dollars are the table in Washington which could be growing a new generation of companies.

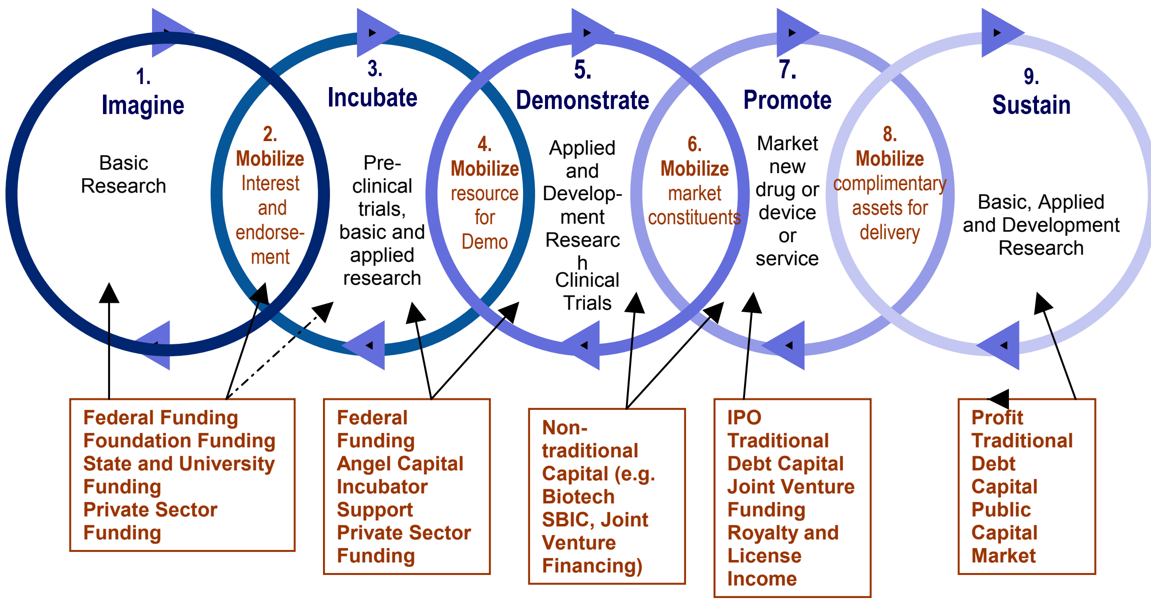
Exhibit 19

INDUSTRY SURVEY RESULTS



It was also recognized by Council members that increasing the knowledge base and the pool of experienced managers with serial life science due diligence is one gap that must be addressed. Though more research will lead to a continuous pipeline of discovery, the lack of managers with prior track records in launching life science companies from those discoveries will ensure that these ideas go to the east and west coast instead for startup (Exhibit 20 illustrates the stages of commercialization).

The Capital Stages of Biotechnology Commercialization



Source: Jolly, Vijay. 1997. From Mind to Market.

Exhibit 20

II. **Where do we want to be?**

Why Innovation is Critical

Central to the Council's charge is recommending how Texas can create the momentum necessary to move ideas from the laboratory to the marketplace and perpetuate biotechnology's "innovation lifecycle" process. In this section, we examine the innovation lifecycle[4], its components, the importance of innovation to the process and the barriers we must overcome to ensure the seamless flow of idea development, ultimately, propelling Texas to the forefront of the industry.

Understanding the Innovation Lifecycle

The biotechnology innovation lifecycle is like a relay race, a seamless, circular pattern with four stages (Exhibit 21) In each stage, the baton must be passed smoothly and skillfully to ensure the successful completion of the cycle (i.e. "lap" of the race) and the beginning of another. Funding, infrastructure, a clear understanding of process and risk, and good business skills all represent strategic batons and potential hurdles in the race to innovate and commercialize.

The goal is a perpetual, self-generating relay that builds momentum with every new lap. A fumbled baton can bring the lifecycle to a halt, threatening the success of both current and future endeavors.

The **Knowledge Creation/Conception** stage is the development phase, which involves idea generation, research and development and patents. Crucial in advancing to the next stage of the lifecycle are internal, federal, "angel" and/or entrepreneurial capital.

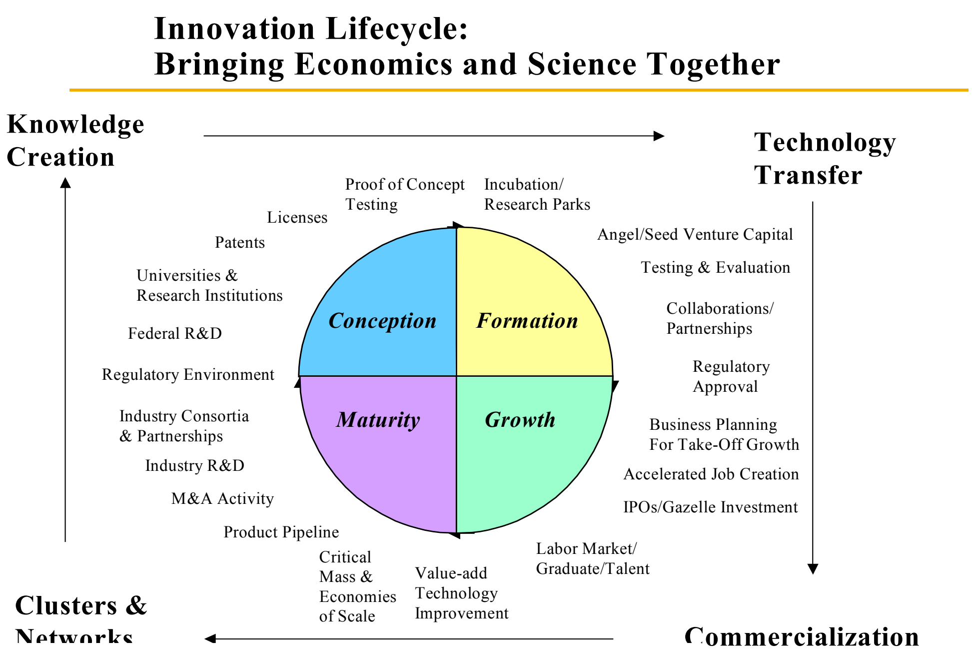
The **Technology Transfer/Formation** stage is typified by clinical trials, regulatory filings and business planning – a phase in which the product/process proves its worth. Entrepreneurial services and support structures, investment capital and partnering are needed to progress to the next stage.

Following clinical trials and regulatory approvals, the product/process enters the **Commercialization/Growth** stage. At this time, a company usually hires additional personnel, files an IPO, and begins early stage production.

At the **Cluster & Network/Maturity stage**, the company begins to perform in a more traditional fashion, analyzing internal business processes for improved efficiency, developing long-term marketing objectives and, most importantly, delivering the product or process to the public.

[4] As developed by New Economy Strategies, Washington D.C. and utilized by the Council in its deliberations

Exhibit 21 The Innovation Lifecycle



Successful movement into the final stage, Cluster & Network/Maturity, lays the groundwork for another race around the track. At this point in the cycle, innovation perpetuates itself - the company commits itself to additional research and development on new products and processes; investors are encouraged to capitalize on this and other science endeavors; educational opportunities in the sciences increase; more infrastructure is created to meet impending demand; and the science arena becomes more valuable as a technology provider, a contributor to improved healthcare, an employer and a partner in economic growth.

Why is Innovation Important?

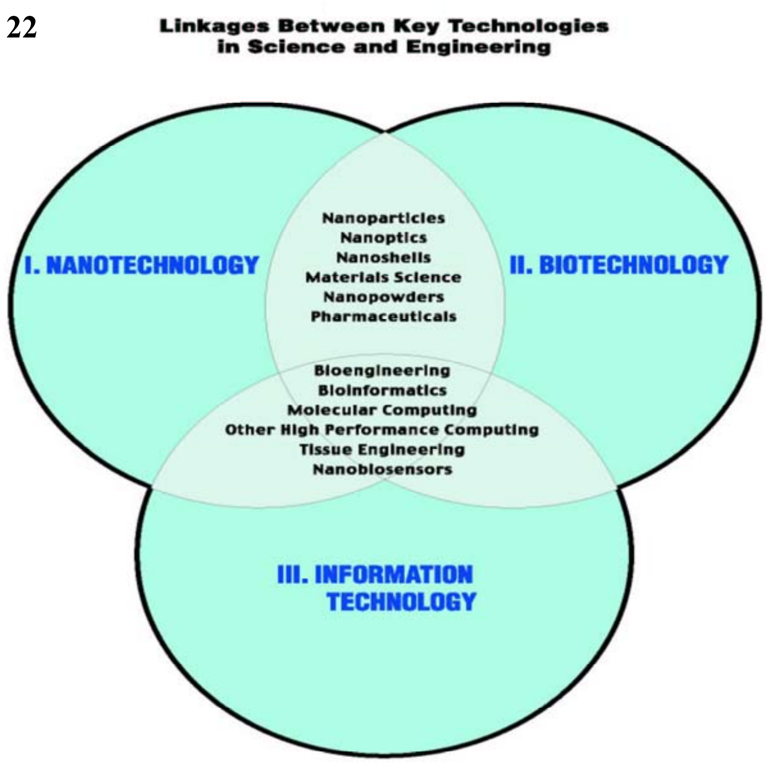
Innovation, according to management expert Peter Drucker is the purposeful response to change. In a period of constant flux, healthcare and life science requires purposeful decision-making and strategies by states and regions seeking to build clusters of economic and technological growth. No longer can haphazard approaches or episodic events drive the necessary collaboration to meet the challenges of a competitive scientific and business marketplace. Innovation of business and economic models is now a critical objective of any industry, especially one as challenging as biotechnology.

Innovation, therefore, is both a purposeful response to the change – and a strategic objective of those creating the environment for competing in the global arena. Such response includes the creation of new structures that can facilitate collaboration by individuals and institutions and accelerate results that benefit all parties. Acceleration of the innovation process requires new interactions – new ways of combining the competencies and knowledge that can lead to new discoveries and team building.

In the life sciences, innovation can be promoted by converging technology and science (Exhibit 22). The combination of biology, information technology, software, and communications has created fields of research and industry that did not exist five years ago. The quickly growing bioinformatics sector is hastening the identification of genes and chemical compounds through increased computing capabilities. Medical devices no longer are just prosthetics or wheelchairs; the emerging fields of biosensors, wireless technologies and advanced materials are likewise transforming the medical device industry. These new sciences are creating materials such as biodegradable transplants and providing once unobtainable information for both patients and physicians.

While innovation is often found within a single firm or institution, it is more likely to succeed in an environment or community setting that offers all the vital elements for success. More than any other industry, the life sciences rely upon partnerships with institutions of higher education and research. Therefore, Texas must foster strong, positive and barrier-free relationships that allow easy exchange of ideas between research facilities. . The proactive mindset and commitment of resources on the part of Texas' academic and medical research institutions is the first step to advancing innovation.

Exhibit 22



Source: Dr. Malcolm Gillis, Rice University

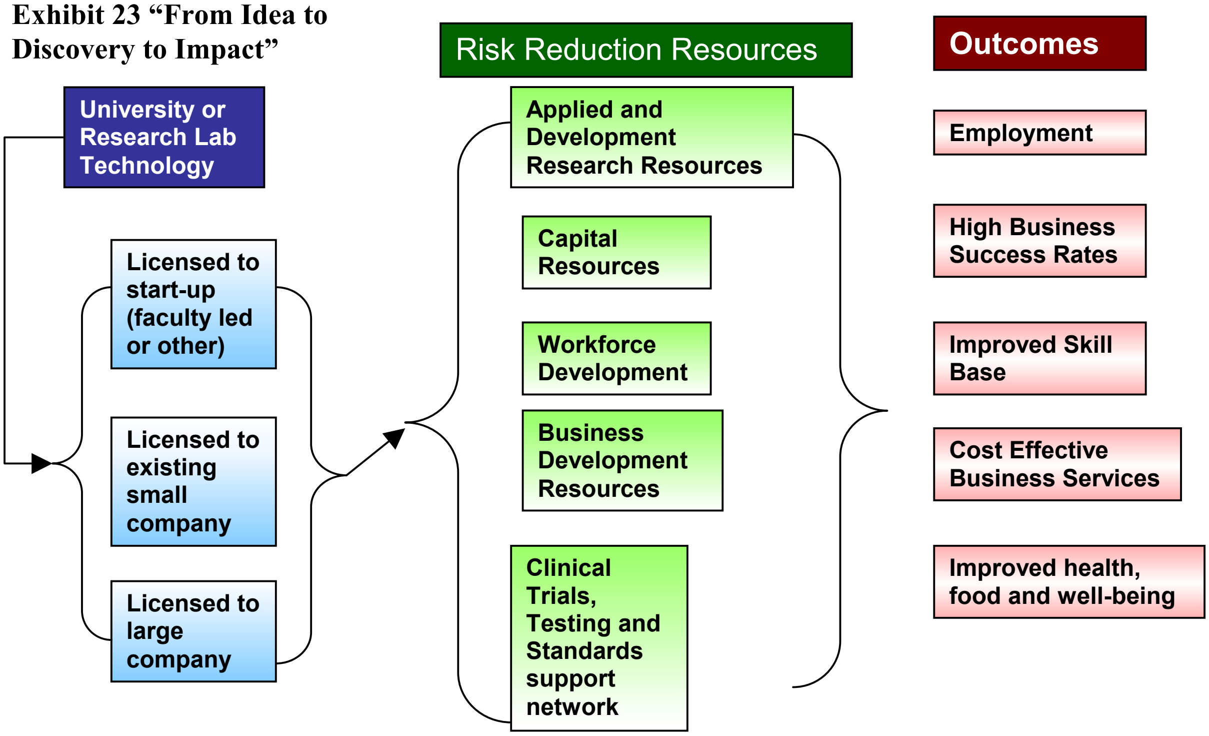
In turn, the ideas generated on Texas' campuses must be allowed to flow relatively unencumbered to those prepared to transform them into tangible patient benefits. Texas regions must be prepared to commercialize research and discoveries by ensuring the capital, infrastructure, talent and skills necessary to support enterprises capable of taking these ideas to market. And over time,

Texas must develop an environment that encourages growing firms to increase their investment in Texas whether by expanding manufacturing facilities, increasing access to markets, providing next-tier capital and otherwise working to create a mature industry that can compete globally. Simply, Texas must foster the churn of ideas into new firms, new firms into growth companies, skills and know-how into the attraction of global companies to Texas — ultimately building the critical mass that will distinguish Texas as a premier location for the life science, biotechnology industry.

Hurdles and Risks

All research, whether performed by a university laboratory or in a corporate environment, involves some degree of risk. Research results may contradict a theory, or offer other disappointing surprises. Success brings with it more risks - the need to secure capital for further testing or technical development, to identify appropriate licensing opportunities and to develop cost-effective manufacturing processes. Each of these represents a potential barrier that can hinder the successful diffusion of research into a commercial product or process.

Exhibit 23 "From Idea to Discovery to Impact"



Source: Meg Wilson, IC2 Institute, University of Texas Austin

Hurdles facing universities include:

- Patent committees with little understanding of market realities;
- A lack of interest in or understanding of intellectual property protection basics among faculty, students and staff researchers;
- Technology transfer offices that lack the resources or mandate needed to act as effective advocates for knowledge and technology transfer;
- Bureaucratic layers of required review and approval that thwart timely action in response to economic opportunities; and
- Inadequate development funding for immature research, which may impede licensing, devalue a license or make a spinout very risky.

Universities also face the challenge of dealing with "orphan" technologies — those developed by researchers who have no interest in moving their own results into the marketplace. Such results can be licensed to new or existing companies, but the university must possess a sound knowledge-transfer process and the technology to ensure successful implementation. Developing such abilities can be difficult, especially if the university fails to provide targeted support for researchers.

The lack of development funding represents a significant barrier for both university research as well as new and small businesses that lack adequate internal resources. The Capital Formation committee found that some funding is available through formal venture capital sources. The committee did not investigate the availability of development or pre-seed and seed funding, but many studies show this stage of funding to be one of the toughest challenges facing research commercialization.

Incubators and "angel" networks help the situation considerably. But Texas' current resources are insufficient to meet the demand of its institutions of higher education and its start-up and young business community. The biotechnology funding challenge is accentuated by the extended time periods involved in various regulatory approvals and clinical trials. In the past 20 years, Texas investors have been forced to adjust their risk assessments from a one- to two-year year profile (oil and gas), to a three- to five-year profile (semiconductors and hardware), to a 0.5 to two-year profile (Internet and software technology), and finally to a two- to 10-year profile for biotechnology applications. Each transition required education and reorientation. Different investors have different tolerances, and Texas' investment community traditionally has favored shorter-term returns. An appropriate role for government in this situation may be to share or lower the risk of long-term private investments, especially since the high-risk profile is due to the need to meet crucial public health-and-welfare requirements.

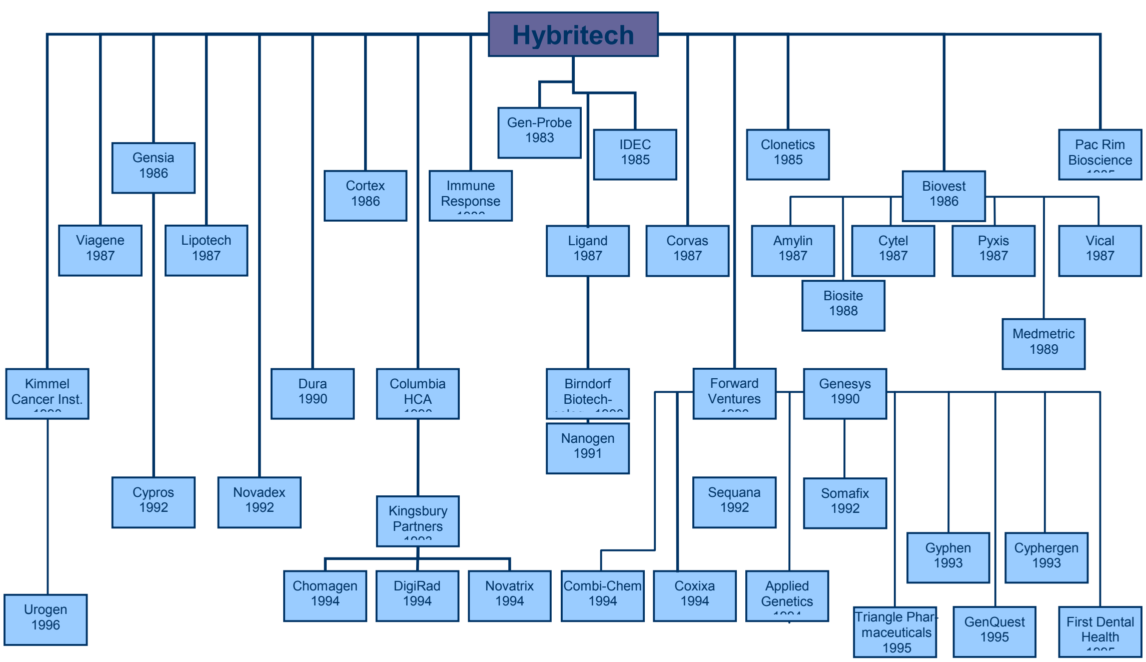
In addition, Texas will need a stronger economic development agency or some equivalent initiative to mount aggressive recruitment efforts and bring new capital and new investors into Texas, especially in new technology fields. A lack of good competitive analysis, market data, infrastructure development and creative regional incentives all discourage major biotechnology business players from entering the state. If we want to keep a substantial portion of the benefits of Texas' research investments in Texas, we must have entrepreneurial and medium- and large-company resources close at hand.

<u>It is not too late for Texas to become a global leader in this race</u>.

We have a superb opportunity, as documented in this report, to attract traditional and new funding sources; develop innovative cooperative proposals and programs among our institutions, business and regions; and provide targeted incentives throughout the innovation lifecycle. And we can aggressively improve educational opportunities for Texans so that both current and future generations can partake of the exciting opportunities that biotechnology and other new technologies offer – high-skill, high-wage jobs, better healthcare and increased prosperity for communities throughout our state.

The Council's use of the Innovation Lifecycle chart in examining strengths, gaps and opportunities provided a glimpse at alternative scenarios for a vibrant life science cluster. What we want for Texas is a lifecycle that "churns" – a sustainable process of accelerating ideas and discoveries into new companies and products. Further, we desire growing and maturing companies to spin-off successive generations of companies as Hybritech did in San Diego's life sciences (see Exhibit 24).

Exhibit 24

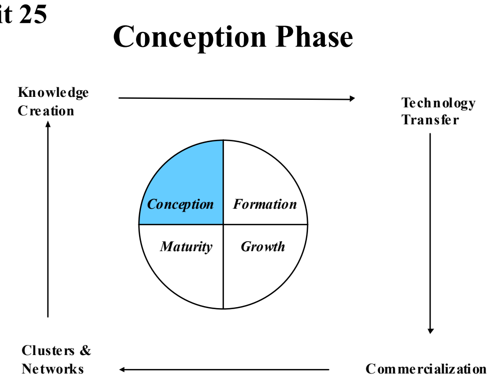


Source: UCSD CONNECT

Addressing the Innovation Challenge

Based on benchmarking best practices across the U.S., the Council has found universal challenges that various Texas stakeholders must address if an innovative environment is to be fostered and sustained. Texas challenges – the hand-offs of the baton between phases – were debated and discussed by the Council, committees, and experts across the State. The following charts provide examples of the innovative process challenges which this report and our recommendations seek to address.

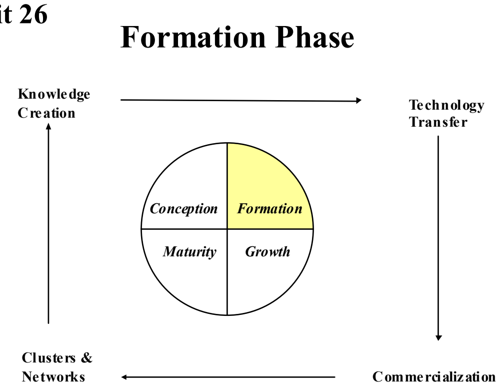
Exhibit 25



Conception (Exhibit 25):

- Critical mass of research dollars, principle investigators, and facilities for basic science work
- Expanding pool of knowledge in basic sciences through increased attention on K-18 learning
- Environments on and off campuses that encourage applied and translational science for the purpose of advancing life science discoveries

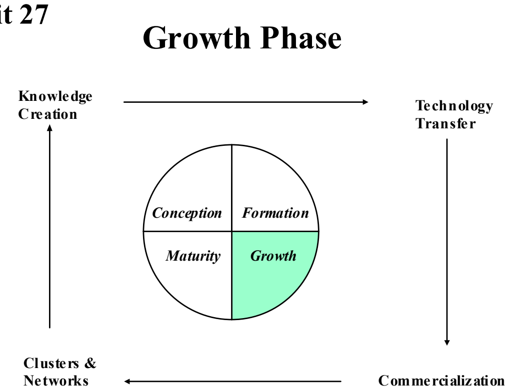
Exhibit 26



Formation (Exhibit26):

- Technology transfer offices and supportive university and institutional leadership with a strong inclination for mutual reward and economic success
- A broader constituency of interests that is both interdisciplinary and collaborative to meet the challenge of convergent technology development
- Pre-seed, early stage, and proof-of-concept monies that leverage patents and licensing of institutional research with regional entrepreneurial expertise and management
- Available workforce to meet the requirements of formative enterprises where initial development, clinical laboratory, regulatory and other vital skills accelerate the time to market.

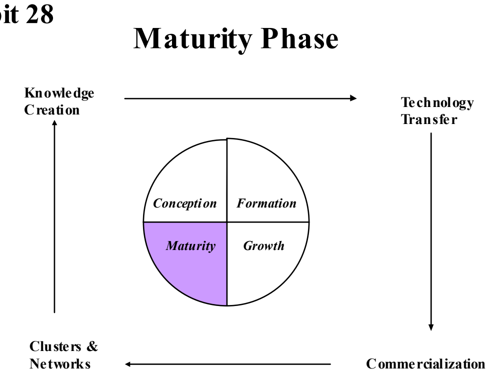
Exhibit 27



Growth (Exhibit 27):

- Appropriate manufacturing resources – especially financial and facilities – to sustain on-going growth
- Experienced managers and a broader pool of skill sets
- Cutting edge research that adds value to initial discoveries and/or builds upon the science within existing products and services
- Access to global customers and relationships to attract merger/acquisition opportunities as well as expanding markets

Exhibit 28



Maturity (Exhibit 28):

- New opportunities in regions for individuals to take their existing competencies and start new companies – simply an environment to foster scientific and economic churn by constantly forming new companies and products
- Senior level expertise in finance and operations on which to leverage growth into global competitive status
- A cluster of vendors-suppliers – the depth of a value chain – that builds the long-term economic proposition

III. How do we get there?

Recommendations of the Governor's Council on Science & Biotechnology Development

To achieve the progress desired by Governor Perry in this charge to the Council, and to leverage the experience and knowledge of its members, four committees analyzed the data and developed a series of specific recommendations.

A single focus of the Council members has been how best to maximize all available resources to convert ideas and discoveries in our research institutions into future investment opportunities that will create economic and societal health benefits for all Texans.

Four committees analyzed the data and developed a series of specific recommendations:

I. Talent and Skills/Workforce
II. Research Funding
III. Technology Transfer
IV. Capital Formation

The Council reviewed the comparative benchmarks from other states and nations, and developed its recommendations using the Innovation Lifecycle as a framework. Each set of recommendations:

- is structured to address the seamless process,
- addresses opportunities or barriers to opportunities,
- incorporates the Council's review comments,
- designates who should lead implementation: the private sector, the public sector or a public/private partnership,
- includes a new category, Infrastructure, due to its revealed importance, and
- includes strategies to achieve those recommendations

These are systemic and long-term recommendations, calling for policies and structures to ensure that Texas has the capacity to grow and excel in the future. Recommendations are presented by committee topic and assigned to one or more stages of the Innovation Lifecycle.

Creating the Competitive Research Agenda

Investing in the regional scientific opportunities

Resulting in the Vital Economic Development: Texas' Health, Wealth, and Jobs

Talent and Skills/Workforce

Recent studies show that Texas students score below the national average for 8th grade science, show no improvement in science scores for 4th graders over four years, and demonstrate a serious gap in scores for girls and minorities in 8th grade science. Texas faces a shortage of science teachers, and teachers who consider themselves well prepared in key science disciplines teach only 35 percent of Texas students. Science and arithmetic are not seen as priorities in elementary education and math and science receive insufficient priority in high school. Through Governor Perry's leadership in 2003, new science tests will be administered in grades 5, 10 and 11. Without a strong foundation in science knowledge and skills, our students will not be prepared for advanced courses such as chemistry, physics and biology.

Recommendation #1:
(Conception-Growth Stages)

Develop strategies to ensure Texas has the workers, research scientists and faculty, and lab space to support industry development. (*Public/Private Partnership)*

Strategies:

- Request legislation to return 100% of indirect costs to research institutions of higher education.
- Work with the legislature, private sector, and federal government to secure funding for exceptional items in higher education for biotechnology and bioterrorism.
- Recruit "star scientists" as magnets for research funding and as catalysts for higher volumes of successful, commercialized technologies.
- Develop programs (such as the Infinity Project) to increase the number of science and engineering students in Texas colleges and universities.
- Make biotechnology-related research areas, particularly molecular biology and genetics, a top priority for funding through the Advanced Technology and Advanced Research Programs.

Recommendation #2:
(Conception –Maturity Stages)

Develop strategies to improve K-12 science education. (*Public/Private Partnership)*

Strategies:

- Work with the existing K-16 Council to coordinate curriculum and course recommendations and the inclusion of science education in the TEKS test.
- Appoint a Governor's Science Advisory Committee and establishing a statewide science development office to provide guidance in programs that can foster opportunities for improvement in scientific education.
- Support the Governor's Science Initiative to:
  - Establish strategies to recruit and retain science and math teachers.
  - Establish programs to train Master Science Teachers.
  - Establish Science Academies to train science teachers on the latest techniques for

science education, using the latest tools and techniques.
  - (Short-term) provide intensive instruction and remediation to eliminate gender and racial gaps in science performance.
  - (Long-term) set high standards for ALL children from their first educational experience. Minorities and girls won't need remedial, tutorial, intervention programs if high expectations are set for them in the first place and they are provided quality instruction to meet those standards. Then, intervention programs can be applied to any poor performers
- Expand mentoring programs for beginning teachers. Support the Texas Teaching Excellence Program (TEXTEP) that rewards teachers with higher salaries if they accept additional responsibilities as mentors of beginning teachers.
- Develop online instructional material with a focus on the building blocks of biotechnology working with the UT Charter School.

Recommendation #3:
(Formation-Maturity Stages)

Develop community and technical college programs to provide an educated workforce for the biotechnology industry as the industry is developed. (*Public/Private Partnership)*

Strategies:

- Work closely with the Texas Workforce Commission
- Use the Skills Development Fund, which provides $25 million of grants to community/technical colleges for customized training for specific businesses and occupations.
- Design a needs assessment tool to measure the general skills required by the Texas biotechnology industry at each entry level.
- Develop a pilot project for a statewide cluster of biotechnology businesses for a training program with community and technical colleges for entry-level training.
- Support the newly proposed "First Generation" college student program with a focus on biotechnology and other high technology careers.
- Offer core courses including biotechnology through the proposed Virtual College of Texas (VCT) core curriculum initiative, seeking new funds to enhance VCT and develop an online-educational core set of courses that will transfer to all public institutions.
- Establish "Centers of Excellence" in biotechnology, applied research, and workforce development to help develop shorter, faster, more focused industry-responsive educational opportunities. There is an ongoing need for an educated workforce, including research faculty at major institutions of higher education and in the biotechnology industry. Texas must concentrate on developing a workforce capable of supporting this aggressive plan of growth in key biotechnology areas. Our human capital must include post-docs, engineers, technicians and experts in business management. Training that

workforce for the broad range of opportunities in Texas will require greater attention to the undergraduate and graduate level courses necessary for working in an industry or an academic setting. Preparing those students to "cross-walk" between academic and industry settings is essential, since many of the emerging sciences and technologies are convergent and interdisciplinary.

Research Funding

Recommendation #1:
(Conception Stage)

Develop new regional "Centers of Life Science Excellence" in basic and interdisciplinary research to leverage regional assets, fill scientific and monetary gaps and encourage greater collaboration among companies, institutions and scientists.
(Public/Private Partnership)

Strategies:

- Combine basic scientific research, innovative thought and the ability to produce the results for market and patient benefit. Creation of Centers of Excellence will encourage critical mass formation at the regional level. Texas is a state of regions with multiple institutions often competing against one another for resources; aggregation or critical mass could lead to stronger, competitive intellectual property development, commercial outcomes and a vital cycle of research competency and excellence. With lead institutions mentoring and supporting the Centers' network of participants, collaborations should lead to successful research and technology diffusion.
- Target Texas' five to seven competitive life science research and development strengths improve ability to become a hub of national and global recognition, as we have in other industries such as petrochemicals, manufacturing and software development.
- Modify Texas' general revenue research funding formula so that state health institutions' general revenue appropriations for research are increased incrementally to achieve a final goal of 20 percent of their research expenditures, as reported to the Texas Higher Education Coordinating Board (as compared to the current rate of 2.5 percent).

Recommendation #2:
(Conception Stage)

Increase Texas' share of the federal funding 'pie', broadening the range of scientific excellence that can be supported, resulting in Texas' heightened competitiveness. The design and implementation of a Texas Federal Funding Strategy is required to successfully increase the scope, breadth, and depth of scientific and technological competencies and key growth areas in the State's life science arsenal. *(Public/Private Partnership)*

Strategies:

- Remove the 'tax on research' by allowing indirect cost recovery to leverage federal dollars for a competitive life science agenda.
- Encourage university researchers to reach across campus boundaries and establish strong working collaborations and develop an

innovative service to review grant opportunities, identify the necessary participants, help build the collaboration and assist in the actual writing and pursuit of grants. The University Research Alliance located in Amarillo, Texas can serve as a model.

- Mount a coordinated effort to place Texas faculty, researchers and public and private experts on the boards, committees and panels in Washington that determine science policy and direction and influence where research funding is allocated. Use this information to guide the research directions for the state.
- Encourage Texans to seek funding through programs such as SBIR/STTR, which are designed to leverage angel and venture capital investment.

Recommendation #3:
(Conception Stage)

Establish R&D Funding Competitions to foster collaborations, emphasizing the importance of linking research funding and commercial outcomes. *(Public/Private Partnership)*

Strategies:

- Use models to design R&D funding competitions, including variations on Texas' successful ARP/ATP, programs in California or Michigan, or expand matching of external research funds in amount and coverage. Account for the connection between the science, technology transfer and key workforce issues within the discovery-to-innovation process, and link Funding Competitions to Centers of Excellence and Collaborative Institutes and to the Federal Research Funding Strategy.
- Analyze the infrastructure necessary to support the discovery-to-innovation linkages. Regions in Texas – both independently and in collaboration – must identify niche opportunities to build specializations. These opportunities will drive critical mass.
- Analyze the federal funds flow and identifying strategic research targets
- Articulate the focus and purpose for the R&D Funding Competitions – faculty research, matching funds for grants, support of research infrastructure, etc. — once the R&D and infrastructure analysis is completed.

Recommendation #4:
(Formation Stage)

Texas should link its existing private sector advantage with academic and entrepreneurial endeavors, finding new ways to leverage that strength through vital partnerships, consortia and joint-sponsored programs in Texas. (*Public/Private Partnership)*

Strategies:

- Create Collaborative Institutes of Applied Research and Commercialization to bridge expertise, experience and resources. These could be linked to the Centers of Excellence recommended above and be a key outlet for applied and development research, as well as a direct bridge to commercialization.
- Explore links between the life science discovery process and mission-oriented research capacities in the private sector. Examples include Houston-based

Schlumberger's smart-card design research and its link with the management of data and knowledge in the life sciences and the health care administration sectors in bioinformatics; and in North Texas, the supportive relationship between wireless and electronics technologies applied to Texas healthcare research and administration. Promoting this interplay between industry and academia will require a formalized approach to increase the likelihood of successful technology transfer and commercialization. The Collaborative Institutes could be incubators for such cooperation and interchange.

Technology Transfer

Recommendation #1:
(Conception Stage)

Create a statewide entity, initially within the Governor's office, to advocate and facilitate technology development in Texas. *(Public)*

Strategies:

- Market Texas as "technology-rich" and "transaction-friendly" in a sustained campaign to get on the preferred list of technology shopping destinations, and conduct independent market studies and a statewide, coordinated effort to sell Texas as an open, transparent and friendly technology marketplace where all are welcome to compete. Statewide focus and assistance from the Governor are needed to bring related and divergent constituencies together to move Texas into a worldwide leadership position in intellectual property and technology transfer.
- Create an entity to assist Texas institutions, clusters and regions in accessing capital and other assets needed for economic development. This body could encourage collaboration and capital sourcing, promote synergies, reduce intrastate competition, and provide statewide marketing and referral structures to academic technology transfer organizations. It would help obtain and coordinate support and cooperation from existing agencies. It also would cooperate with regions and technology cluster groups, helping them obtain funding and other resources from a variety of sources, much as the State Tourism Office supports local chambers of commerce and regions. In addition, this body could:
  - Act as a unified voice to advocate Texas science and biotechnology within the state and in Washington, and as a neutral, positive force to help Texas institutions bridge intrastate fragmentation, competition and resource gaps.
  - Gather data and maintain strategic information systems to assist technology producers and users.
  - Engage in marketing activities to aggressively present Texas as technology-rich and transaction-friendly and promote Texas as a venue for locating mid-sized biotech companies and large company divisions.
  - Identify and help unlock assets within the state to support science and biotechnology economic development,

including grant funding in a variety of related fields. As part of this effort, it could link Texas institutions and regions as advisable; develop seed funding for technology start-ups; provide infrastructure and financing mechanisms for regional technology parks and incubators; assist local and regional efforts to develop know-how networks and related infrastructure; and develop bonding authority to assist regions and technology clusters with economic development.
- Advocate investment by TEXPERS members, working with TEXPERS and "gatekeepers."

Recommendation #2:
(Conception-Growth Stages)

Create continuity and leadership for Texas science and biotechnology development. (*Public)*

The Governor should appoint a respected business leader knowledgeable and accomplished in the fields of science and biotechnology to lead the effort to implement the Council's recommendations. The leader would serve at the pleasure of the Governor and would be charged with taking the recommendations forward and building upon the foundation established by the Council. The Governor should strongly articulate a vision of commitment to continuity and sustainability to implement a 20-year plan of action.

Texas passed landmark legislation supporting university commercialization in the 1980s and reiterated support for these approaches in 2001. However, Texas universities and their TTO operations need to 1.) Increase their sophistication and dedication to technology transfer particularly in biotechnology fields; and 2.) Build on experience that Texas has gained since the passage of the federal Bayh-Dole Act and Texas economic development and university commercialization legislation to propel Texas into the forefront of university technology transfer.

Recommendation #3:
(Formation Stage)

Academic institutions should adopt competitive practices for technology development and transfer and provide the resources adequate to be competitive. *(Public/Private Partnership}*

Strategies:

- The Texas Governor should:
  - Require understanding and advocacy of science and technology development issues of nominees for university boards of regents.
  - Ask the Legislature to underscore that the mission of state academic institutions includes economic development based upon commercialization of research. This position has been promoted elsewhere to great effect.
  - Urge the Legislature to abandon reimbursement of indirect costs to the state. Texas universities should be allowed to keep all grant funds from research. One possible use of these funds would be to support technology transfer

offices. An alternative is to request funding for these offices through a special item budgetary allocation over and above other state funding for education institutions.

- Texas universities should:
  - Develop and encourage cultures, policies and structures that support entrepreneurial faculty, top-quality innovative research, groundbreaking innovative inquiry, and technology transfer best practices for the intellectual property protection and commercialization.
  - Include understanding and advocacy of science and technology development issues as key criteria for selecting departmental chairs, university administrative officers and key faculty.
  - Adopt tenure policies supportive of innovation and entrepreneurship to reward and legitimize the activity of research with commercial relevance, recognizing that technology transfer efforts are often pursued at the sacrifice of more traditional tenure-earning activities.
  - Urge technology transfer offices to adopt sophisticated public relations models and disciplines in interactions with faculty and external parties.
  - Provide open and transparent processes that make technology licensing competitive within the marketplace, and reconfigure the economic division of licensing income to be competitive with best-practice states.

Current Technology Transfer Options in the Academic Arena

- University and researchers hold equity – team stays at university. Existing company offers equity in lieu of certain license fees. (Equity/Exclusive Licensing deal)
- University and researchers hold equity – team contracts with company to support venture (Equity/Exclusive Licensing/Research deal)
- University and researchers hold equity – key researchers are hired by licensing company (Equity/Exclusive Licensing Deal)
- License deal, no equity, team stays at university. (Exclusive Licensing deal)
- License deal, no equity, team stays at university. (Non-Exclusive Licensing deal)
- License deal, no equity but sponsored research contract signed with university (Exclusive Licensing/Research deal)
- License deal, no equity but sponsored research contract signed with university (Non-Exclusive Licensing/Research deal)

Source: Meg Wilson, IC2 Institute, University of Texas Austin

Capital Formation

Recommendation #1:
(Formation Stage)

The Governor and the Legislature should use their authority to increase the availability of in-state pre-seed/seed and development-stage venture capital targeted for investment in intellectual property for both human health and agriculture. ***(Public)***

Strategy:

- Allocate up to one percent of assets managed by state university endowments and pension funds to venture capital and investment firms whose strategy is pre-seed/seed and development stage investment in biotechnology target markets. The investment decision-making process should be consistent with each fund's current, established investment review procedures. Commitments should favor Texas-based investment firms or those out-of-state firms that make tangible and verifiable commitments to pursuing investment opportunities in Texas or the establishment of a local presence in the state.

Biotech companies prefer to locate in areas that offer tax abatements, other tax advantages and infrastructure support. In addition, key players, from universities to large companies, need specialized outsourcing capabilities for research, testing and clinical trials. Incentives to promote creation of such partner incentives and services are needed.

Recommendation #2:
(Formation Stage)

Provide added economic incentives to the private sector, such as facilities grants, to supplement incentives provided by municipalities to:

- Attract up to four major pharmaceutical/biotechnology research facilities to Texas.
- Build sufficient incubator space and create research parks to accelerate the development of healthcare, biotechnology, medical device and agricultural start-up companies. **(*Public-private partnership)***

Infrastructure

Recommendation #1:

(Formation Stage)

Create an appropriate mechanism for State funds to be provided for land acquisition, laboratory construction, utilities, maintenance, etc. for biotech incubator parks or low-cost private laboratory space associated with State health science centers and general academic campuses that are active in biotech-related research; such State appropriations should be in addition to funds provided locally. ***(Public/Private Partnership)***

Recommendation #2:

(Formation Stage)

Establish State tax incentives for existing biotech companies to move to Texas and for biotech start-ups to be established in Texas, to supplement tax incentives offered by local communities. ***(Public)***

Although the Biotechnology Council did not directly address the role of medical privacy in its deliberations, it is aware of a serious barrier to biomedical research that looms at the federal level and exists, in explicit form, in Texas law. The Governor's Science and Biotechnology Council lend its support to remedy of this serious disincentive to public and private clinical research. Exhibit 29 on page provides a summary of the Council's recommendations.

Exhibit 29

Summary ofRecommendations

	Conception	Formation	Growth	Maturity
Research Committee	Develop **Regional Centers of Life Science Excellence** in basic (and where appropriate interdisciplinary) research	Link private sector with academic and entrepreneurial endeavors: **leverage partnerships, consortia, and joint sponsored programs. (e.g. Collaborative Institutes of Applied Research and Commercialization**		
	Design and implement a **Texas Federal Funding Strategy**			
	Establish **R&D Funding Competitions**			
Technology Transfer Committee	Create a statewide entity, initially within the Governor's office, to advocate and facilitate scientific technology development in Texas.			
		Academic institutions should adopt competitive practices for technology development and transfer and should be provided the resources adequate to be competitive		
	Create Continuity and Leadership for Texas Science and Biotechnology Development.			
Capital Formation Committee		Increase the availability of in-State pre-seed/seed and development stage venture capital targeted for investment in intellectual property for both human health and agriculture.		
		Provide additional economic incentives to private sector developers in the form of outright facility grants, or otherwise, to supplement incentives currently provided by municipalities		
Talent & Skills Committee	Develop strategies to improve K-12 science education			
		Work with the Texas Workforce Commission to prioritize the biotechnology industry for training programs. Develop community and technical college programs to provide an educated workforce for the biotechnology industry as the industry is developed.		
	Develop strategies to insure that Texas has the workers, research scientists and faculty, and lab space to support industry development.			
Infrastructure		Create an appropriate mechanism for State funds to be provided for land acquisition, laboratory construction, utilities, maintenance, etc. for biotech incubator parks or low-cost private laboratory space		
		Establish State tax incentives for existing biotech companies to move to Texas and for biotech start-ups to be established in Texas		

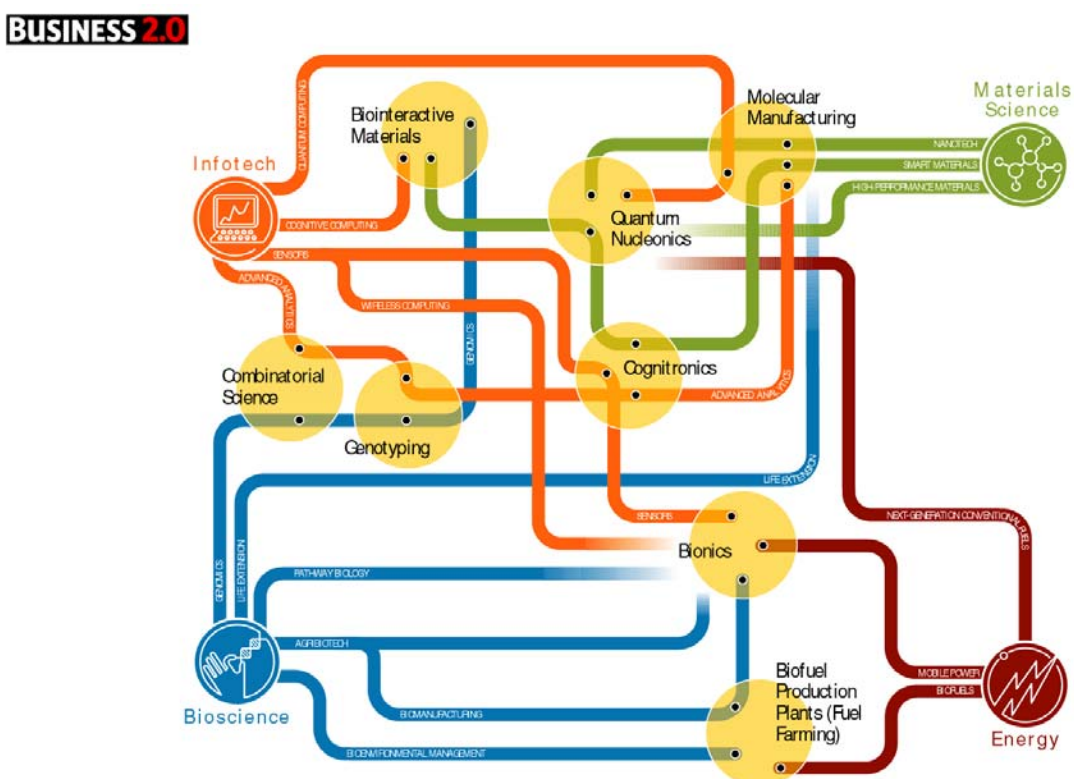
IV. Emerging Technologies

The Council's initial analysis of Texas' research investments, science competencies and technological strengths suggest that the state can build successful industries in six life science disciplines and can become the global leader as we have done in previous technologies.

1. Nanotechnology
2. Vaccines
3. Molecular Sciences
4. Advanced Materials and Manufacturing
5. Animal and Plant Modeling
6. Wireless Information Technology

Each of these sciences combines technologies in which Texas has demonstrated expertise: information/computation, materials, energy/environment and biology. For example, nanotechnology may combine material science, information/computation and biology. Similarly, computer modeling and 3-D graphic capabilities are indispensable to plant and animal modeling (Exhibit 30).

Exhibit 30



Texas has remarkable strength in each of these convergent sectors, from super-computing capacities to our emerging strength in molecular and nano-material development. And since these capabilities are vital to numerous areas within the life science industry, including pharmaceutical, biotechnology, medical devices, healthcare services and administration, and plant and animal studies, Texas seems well positioned to create unique industries that other regions may come to depend upon for their own success.

High "Throughput" Advantage

The state's ability to compete effectively within these six disciplines will depend upon the development of "high-throughput" abilities — that is, the ability to move ideas from the laboratory to the marketplace rapidly and efficiently.

Given that taking a chemical compound from the lab to the marketplace can require eight to 12 years and cost approximately $250 million to $500 million, finding ways to accelerate the drug discovery process has become a major goal for investors, companies and the healthcare community. Increased consumer expectations are driving the development of new tools, new technologies and new sciences capable of reducing cycle times and costs in the quest for better products.

A Brooking Institution report, *Signs of Life*, identified nine "first wave" regions in the U.S. that possess high-throughput capabilities. While Texas was not listed among this initial nine, the report noted that a second wave of competency and opportunity may be unfolding for the life sciences, one that will rely on converging disciplines and 'high throughput' scenarios.

By building on our present strengths and committing to the development of innovative techniques for accelerating the lab-to-market process, Texas can lead this second wave.

Unique Opportunities for Texas Life Sciences

Nanotechnology (Near-term: Energy; Long-term: Medical Scenarios)

Nanotechnology consists of research and technology development at the atomic, molecular or macromolecular level to gain understanding of nanoscale phenomena and materials and to create and use structures, devices and systems with novel properties and functions because of their small size. While the ultimate implications of nanotechnology are virtually limitless, actual processing and manufacturing of nanoscale elements are in their earliest stages, and their applications for industries — ranging from energy/environment to microelectronics to healthcare — are still being examined.[5]

Texas has made unique contributions to the growth of the nanotech industry due to the leadership of Nobel laureates Dr. Richard Smalley of Rice University and Dr. Alan G. MacDiarmid of the University of Texas at Dallas. Our state

[5] A complete strategic analysis of the nanotechnology field and its capacity for growth in Texas will require additional study of current energy, environment, and microelectronics research and the patent process.

could leverage this expertise through additional support for fledgling nanotech activities such as the Texas Nanotechnology Initiative, the NanoTex effort, and the SPRING academic-driven research consortia.

In addition, Texas could begin bridging the gap between discovery and final application by coupling the capabilities of Texas A&M's engineering and manufacturing programs with investments at UT Austin and UT Arlington,. At present, however, these institutions' programs are neither connected nor appropriately funded.

Other regions in the U.S. have been identified as nanotech centers of excellence and have received recent federal funding through such programs as the Defense Advanced Research Project (DARPA). Texas must make significant investments in new facilities, manufacturing rooms and skill development to maintain its current advantage in nanotech.

Vaccines (Third-World challenges, Future bioterrorism threats)

Vaccine research and production requires unique facilities and science capabilities, both of which are abundantly available in Texas. San Antonio's military bases, life science and healthcare facilities, and its Level 4 toxic center, provide an outstanding basis for creating, analyzing, mass-producing and maintaining the security of vital vaccine derivatives needed to protect the American public. Given the immediate threat of bioterrorism, the largest opportunity for Texas' competitiveness may be in the production of vaccines for the Third-World diseases that plague those nations and threaten health in the western world.

From AIDs/HIV prevention to therapeutics for cancer and blood disorders, the worldwide demand for vaccines will only grow. And Texas is well-positioned to become a significant competitor in vaccine discovery and production, especially given the recent arrival of a former Army Surgeon-General and nationally recognized vaccine expert, to act as the University of North Texas Health Science Center president. A Texas Consortium on Vaccine Research could combine knowledge with the exceptional vaccine programs of the Southwest Research Institute, UT Galveston and other institutions to create a highly competitive vaccine development industry.

Molecular Science (Next Generation Genomics/Proteomics)

Genomics — the study of gene structure and its relationship to biological function — and its companion science, proteomics — the study of protein expression in normal and diseased tissues — will further the understanding of DNA's role in combating disease.

While Texas was one of three initial research sites (Baylor), it has not sustained significant federal dollars from the Human Genome Project ($150 million over the past nine years). Yet, many Texas research institutions have found alternative genomics funding for the study of a variety of diseases such as cancer, Alzheimer's disease, heart disease and neurological disorders. This expertise should allow us to accelerate clinical trials in chemistry and compound research, leading to new drug development and genetic therapies. Strength in molecular science does not represent merely a pharmaceutical opportunity; the creation of new fibers, seeds, pest management, and animal health also would benefit Texas' agricultural and veterinary industries.

Given the proficiency of M.D. Andersen and the Baylor College of Medicine in cancer treatment, North Texas institutions' expertise in tissue engineering and Texas A&M's extensive knowledge of animal and plant genomics, our state is positioned to coordinate its efforts through the creation of a statewide Institute of Genomics and Proteomics.

Wireless-IT Health Care Administration (From Telemedicine to BioSensors)

Three Texas areas have strengths that, if combined, could give the state a significant advantage in information technology arena as it pertains to healthcare services, administration and management.

The Telecom Corridor of North Texas (Richardson, Plano and North Dallas) and its wireless engineering expertise; the computational sciences and software capacities of Austin; and the Texas presence of major corporate players such as Dell Computer, Texas Instruments, and Hewlett Packard/Compaq (recent developers of IPAQ hand-held computers) all combine to offer strong academic and industry credentials for serving hospital administrators and patients alike.

Additional work will need to be done. Texas' current efforts in telemedicine, for instance, will require additional resource. Texas also needs to further analyze its sensor technology and engineering capabilities to determine its competitiveness with other regions. Biosensors, in particular, are becoming vital tools in air pollution prevention and control as well as the detection of air-borne bioterrorism threats. A Healthcare Information Technology Collaborative could create new opportunities in computer science, software and wireless engineering, telecommunications, and health care administration.

Animal and Plant Modeling (Genetic Cloning and Food Safety Issues)

Texas A&M, Texas Tech, West Texas, UT Tyler and several other institutions' work in animal and plant modeling is fast becoming globally recognized. Animal modeling is particularly desirable considering widespread controversy concerning both cloning and the use of live animals for research purposes. Advanced computational sciences, visualization, 3-D graphics and other design tools are greatly enhancing our ability to create animal and plant computer models and simulate their reaction to various stimuli. This expertise and our developing ability to modify animal and plant genetic code to create strains with specific traits (such as the ability to survive extreme conditions) put Texas institutions in an enviable position. A statewide Animal and Plant Modeling Initiative would help the state leverage this scientific and technological knowledge by linking institutions with varying skills and tools.

Advanced Materials and Manufacturing

Texas' century-old petrochemical and energy industry made it a world leader in materials innovation and large-scale manufacturing — expertise uniquely suited to the life science industry. The design and production of new medical devices from lighter, stronger and less expensive materials will require in-depth experience in materials and manufacturing, as will the creation of organic materials for applications such as tissue engineering (in which scaffolding materials must respond to the needs of varying cellular structures) and information tools (in which microelectronics, wireless technologies and sensor capabilities will become critical.)

The University of Houston, Southern Methodist University, UT-Austin, UT-Arlington, the Balcones Research Center and other entities could provide the basic and applied science needed to establish several programs designed to increase our value to the life science industry, such as a Texas Bioengineering Program and a Texas BioManufacturing Program.

Additional Areas

We have identified four additional areas of science research federal funding to Texas – Advanced Computing, Electronics, Advanced Materials, and Environmental Technologies. These areas of science are just beginning to converge with and be impacted by biology and the life sciences. The basic science research in these areas – especially in non-medical academic institutions – provides the connection between the hard sciences and the economic models emerging for new opportunities. We need students and faculty that achieve competency in basic areas of research that can be leveraged with biology to develop the next generation of products and services. And we recognize that multiple areas of science can benefit from strengthening our life science capacities that will impact traditional areas of Texas' economy – from energy and the environment to the computer and electronics sector (see Exhibits 31 to 34).

1993-2001 Unrestricted R&D Funding to Texas in the Advanced Computing Sector (Total=$0.108 Billion)

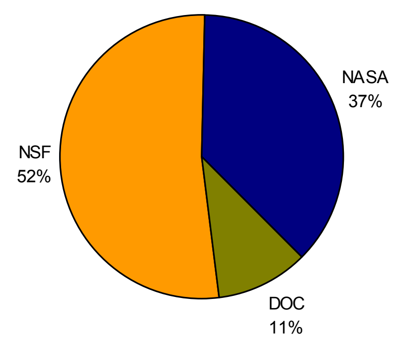


Exhibit 31

1993-2001 Unrestricted R&D Funding to Texas in the Electronics Sector (Total=$0.008 Billion)

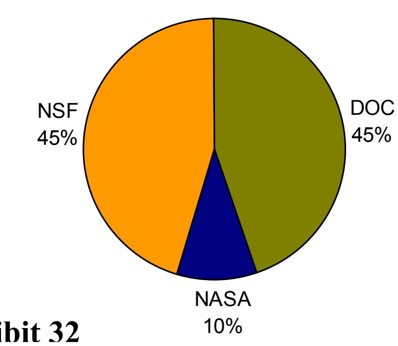


Exhibit 32

1993-2001 Unrestricted R&D Funding to Texas in the Advanced Materials Sector (Total=$0.123 Billion)

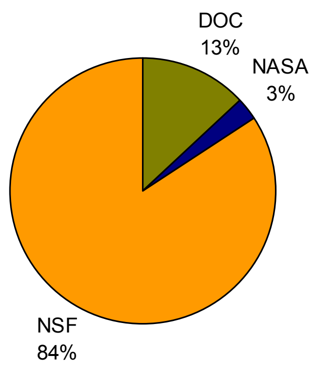


Exhibit 33

1993-2001 Unrestricted R&D Funding to Texas in the Environmental Technologies Sector (Total=$0.108 Billion)

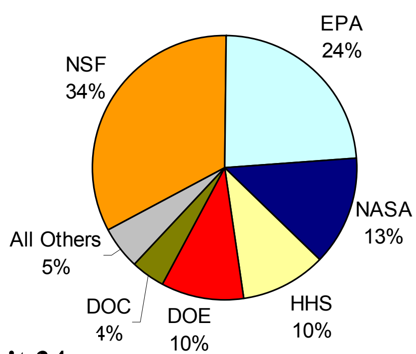


Exhibit 34

V. Framework for Actions

Sustainability for Growing the Texas Life Science Cluster

Objective: Sustain the work of the Governor's Council, connect resources statewide (research, commercialization, institutions, infrastructure, entrepreneurs and resources), and promote and market the state's life science assets.

Specific focus: development of a sustainable mechanism for the life science cluster

A sustainable mechanism must be instituted that can leverage Texas' many strengths by connecting wells of knowledge and resources throughout the state, including people, places, opportunities and research and development abilities.

This mechanism should consist of public-private partnerships that link the Governor's Office with an external 501c3 Foundation, which can be the repository for grants and gifts to support the statewide Office of Life Sciences/Biotechnology. For this partnership to succeed, the public side must have some authority (inclusive of the seal of the state) and some teeth by which it can get its job done.
The partnerships would:

- Promote and market Texas' life science assets, constantly seeking appropriate matches between academic institutions, industry, and regional economic development opportunities while telling the "Texas Story" in various venues and communications settings.
- Encourage commercialization by providing information and assistance to tech transfer offices.
- Recruit global life science companies for relocation or expansion in Texas, and encourage universities, and regions to consider collaborative opportunities in Texas.
- Collect, analyze, and disseminate data to effect appropriate polices, strategies, and tactics in support of the life sciences.
- Drive a statewide federally funded research strategy to increase federal investments in Texas' institutions, researchers, and regions.
- Champion the life science cluster before various state and federal agencies and the general public.
- Facilitate regional collaboration by linking regional strengths, assisting in recruitment efforts, providing appropriate data, and assembling state agency resources (workforce, regulatory-permitting, economic development).
- Provide guidance and counsel to the Product Development Fund

We suggest the creation of a Life Science Task Force of five to eight individuals representing the Governor and 10 to 12 on the Foundation Board. This partnership will help focus resources on and foster sustainable action around the six Targets of Opportunity.

No state dollars would be used for this initiative at first, only the existing fund for implementation in the focus areas, such as work force.
Later, however, the partnership would counsel the governor on how state funds could be used most effectively in this regard.

VI. Appendices

APPENDIX A

ADDITIONAL RESEARCH FINDINGS AND DATA: RAND RADIUS, COORDINATING BOARD, AND INDIVIDUAL COMMITTEE DATA COLLECTION

The following elements of data represent a comprehensive collection of important and new findings on the current life science situation in Texas. Through several sources, we now have a better idea of the assets as well as the opportunities for competitiveness. The Texas Higher Education Coordinating Board, the Texas Workforce Commission, the Texas Department of Economic Development among others can and should provide the basis for on-going data collection and analysis.

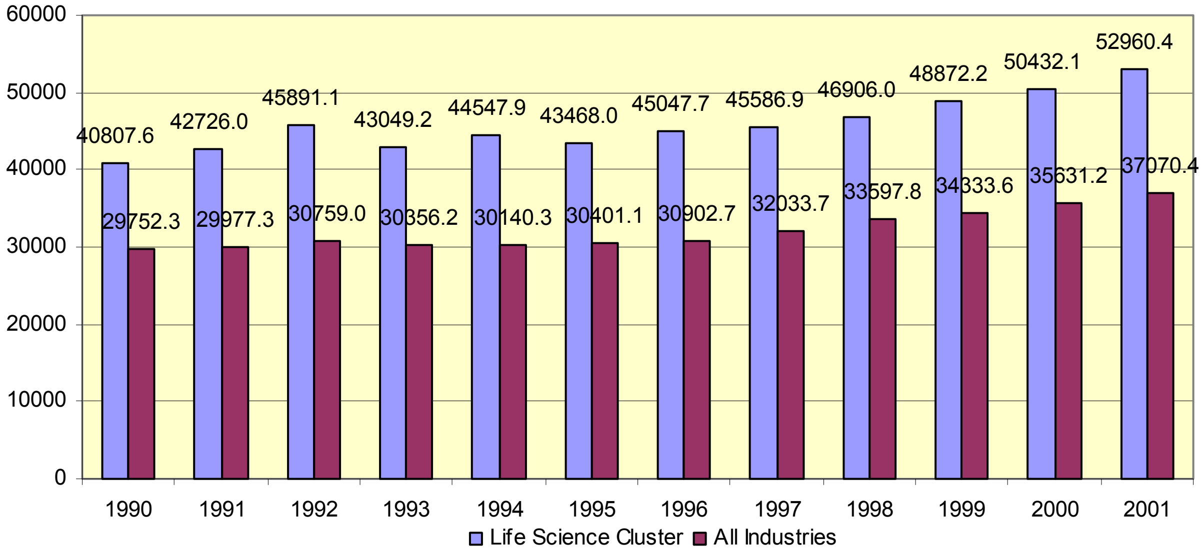
But this knowledge must be complimented by a constant acquisition of new knowledge from the RAND RADIUS database, from individual companies and regional economic development entities, and from a consistent monitoring of global science and market trends.

On the following pages unfolds a compelling story that describes strengths and gaps as well as assets and opportunities for Texas' 21st century life science cluster. A few highlights should indicate to be the reader that Texas must now act to be a global leader:

- We have a life science industry that exceeds both state average wages and is just below the national average. The industry can attract the competitive workforce it needs based on these wage levels and the consistent levels of growth since the 1990s.
- We know that most companies in Texas and the U.S. are relatively small – a majority of these companies are privately held. The sub-cluster segment with continuous growth in company formation is laboratories and research – suggesting that Texas is positioned well in clinical trial and research support but now must focus greater attention to commercialization and product development.
- Texas's NIH funding has concentrated in a handful of science sectors – cancer, heart, general medicine – and receives the greatest share. Of concern to Texans should be the 6% in genome research and 6% from infection diseases. Based on current trends, Texas must increase its attention on fostering greater shares of genomic and proteomic dollars while organizing efforts to target the bioterrorism funding that will be managed by the Institute for Infectious Diseases.

Exhibit A1

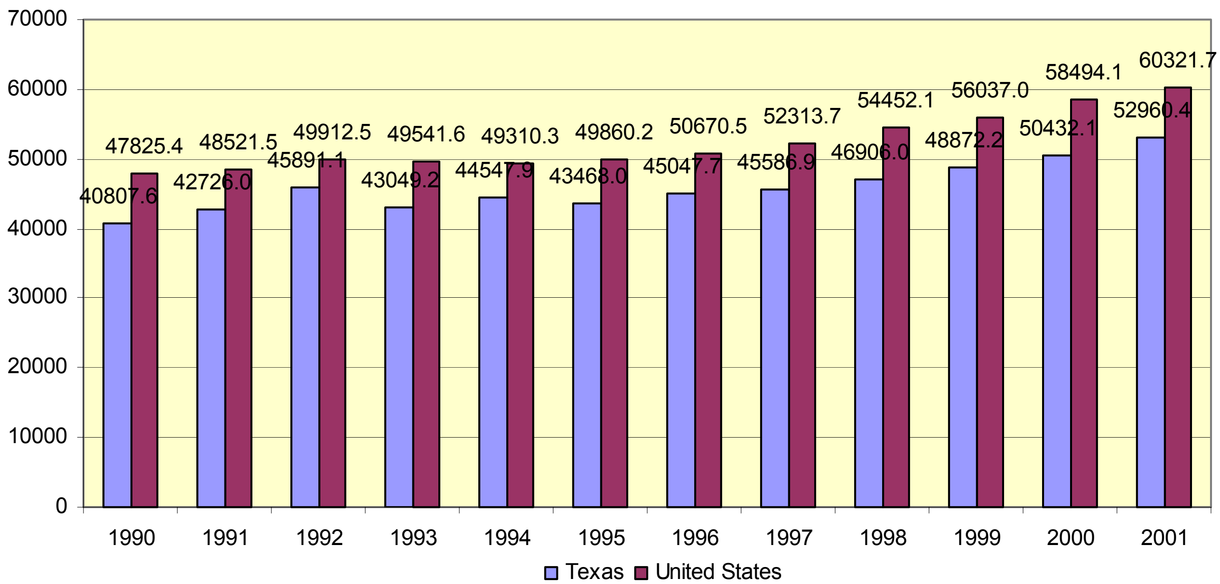
Texas Healthcare Technology Cluster and State Wages, 1990 to 2001



Average w age per employee for the Texas Healthcare Technology Cluster compared to the state average, 1990 to 2001 (2001 dollars)

Exhibit A2

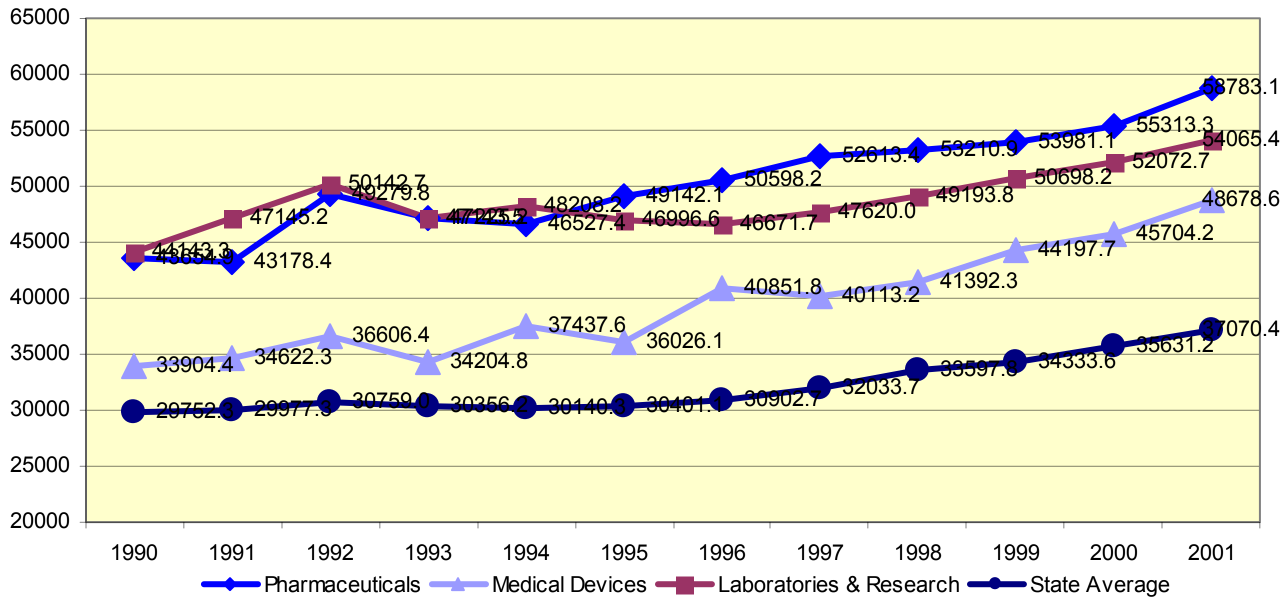
Average Wage Per Employee, Texas and United States Healthcare Technology Cluster, 1990 to 2001



Average w age per employee in the Healthcare Technology Cluster, Texas and the United States, 1990 to 2001 (2001 dollars)

Exhibit A3

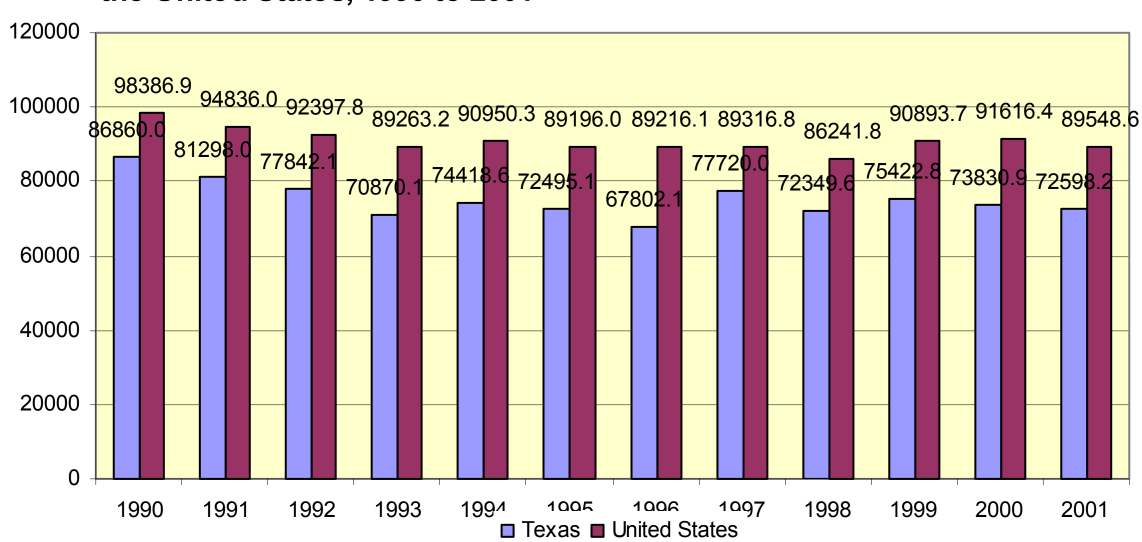
Texas Healthcare Technology Industry Segments and All Industries Average Wage Per Employee, 1990 to 2001



Average wage per employee for the major segments of the Texas Healthcare Technology Cluster and the state average, 1990 to 2001 (2001 dollars)

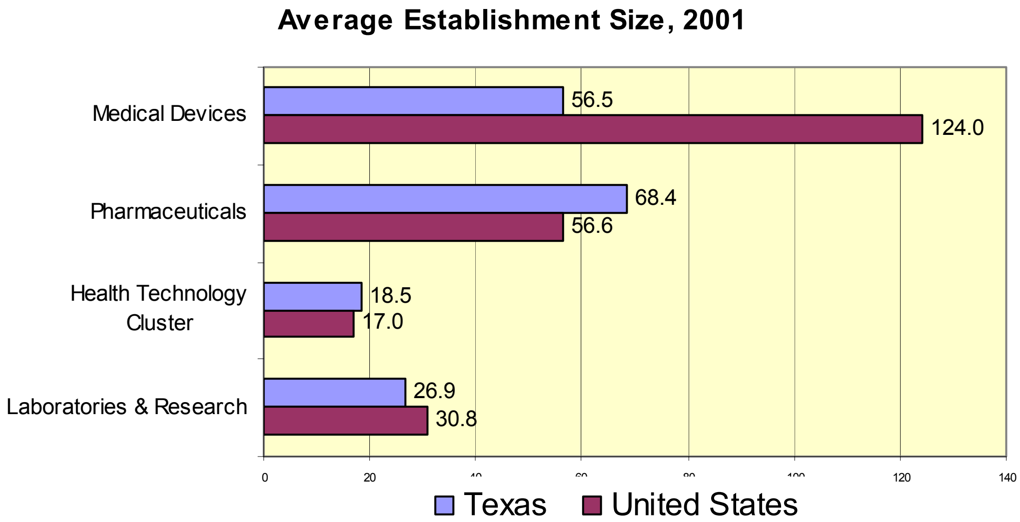
Exhibit A4

Healthcare Technology Cluster Value-Added Per Employee, Texas and the United States, 1990 to 2001



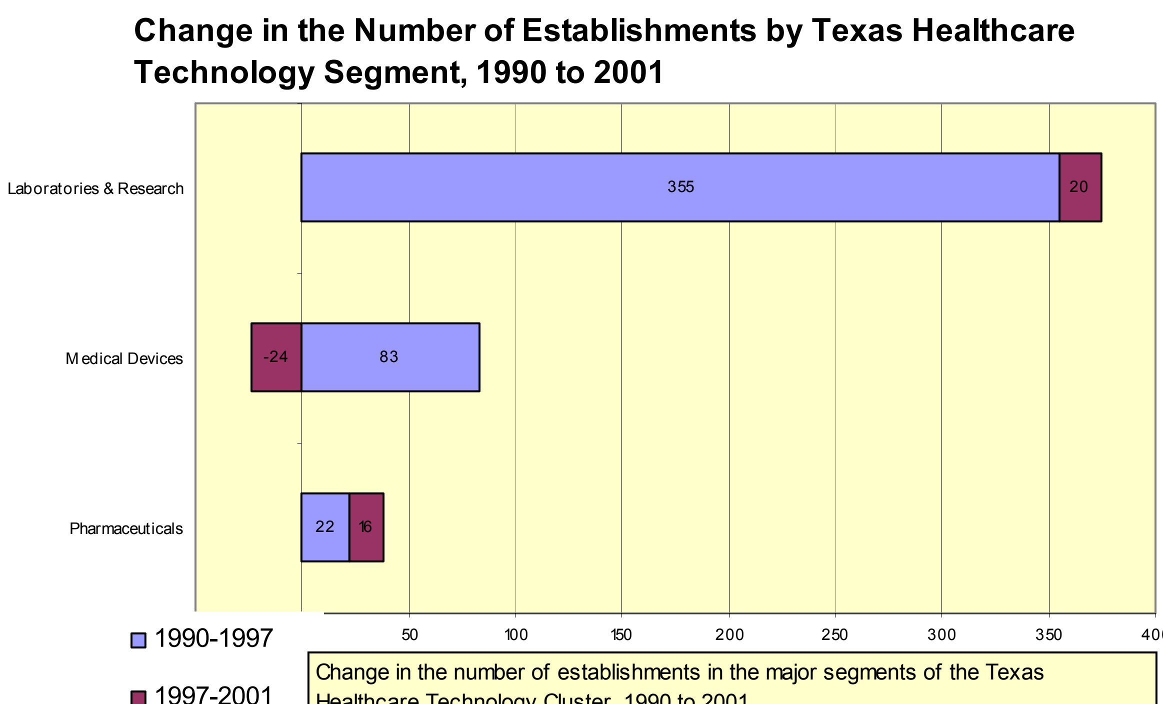
Value-added per employee in the Healthcare Technology Cluster, Texas and the United States, 1990 to 2001 (2001 dollars)

Exhibit A5



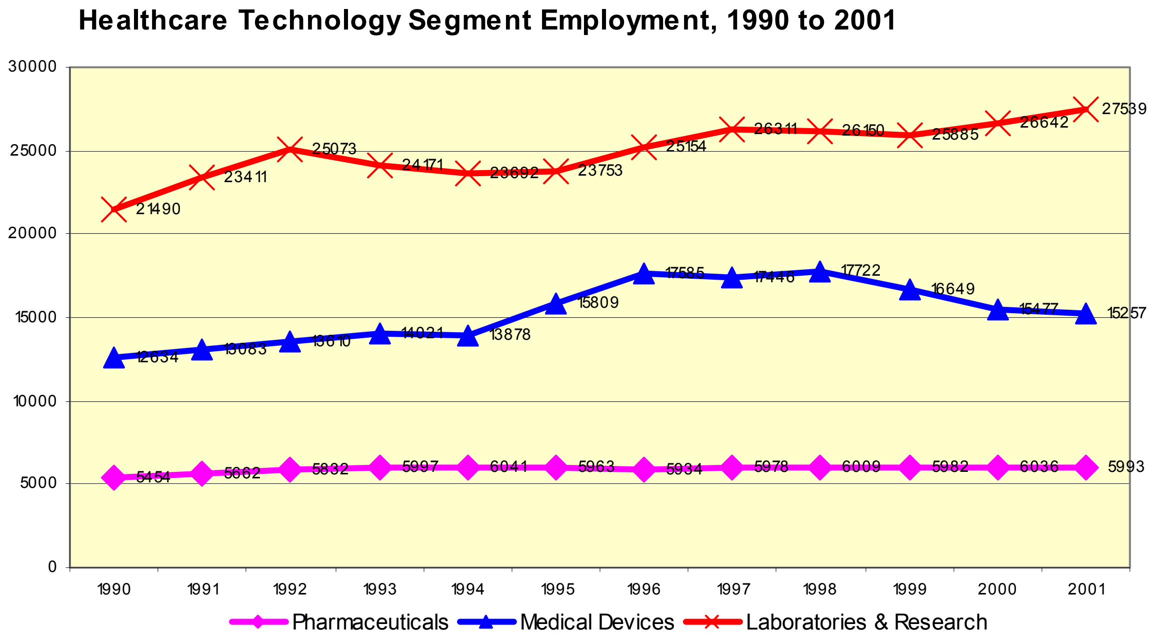
Average establishment size for segments of the life science cluster, Texas and United States, 2001

Exhibit A6



Change in the number of establishments in the major segments of the Texas Healthcare Technology Cluster, 1990 to 2001

Exhibit A7



Employment in the major segments of the Texas Healthcare Technology Cluster, 1990 to 2001

Exhibit A8

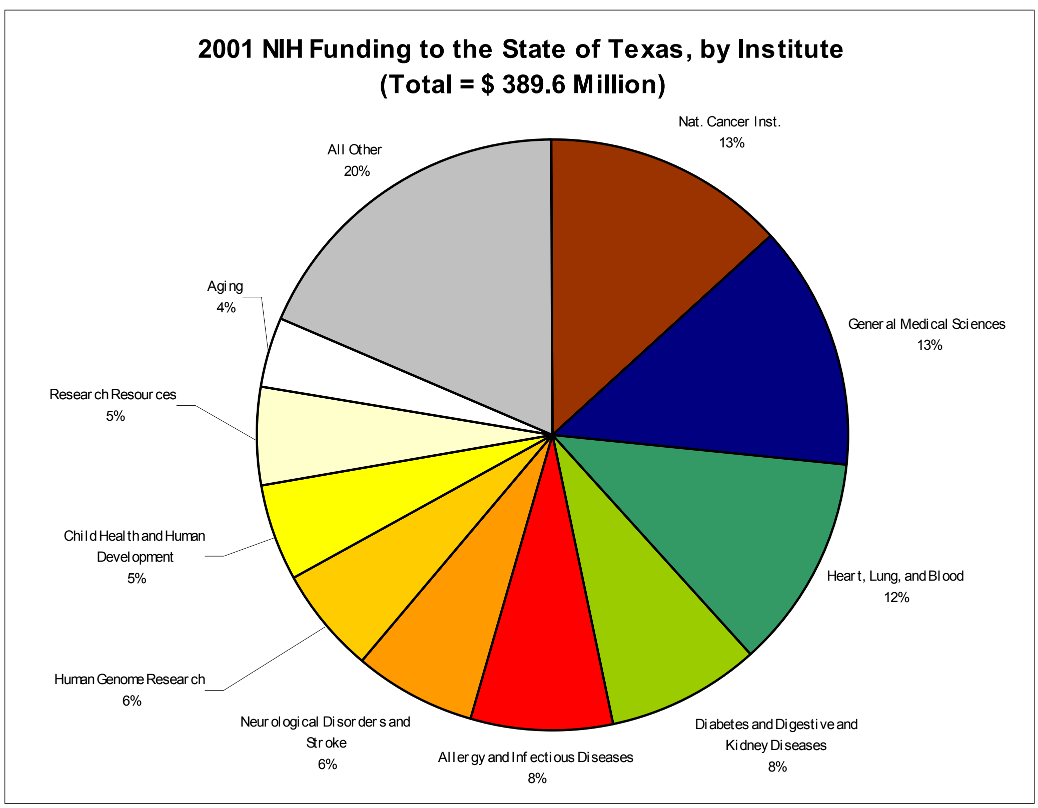


Exhibit A9

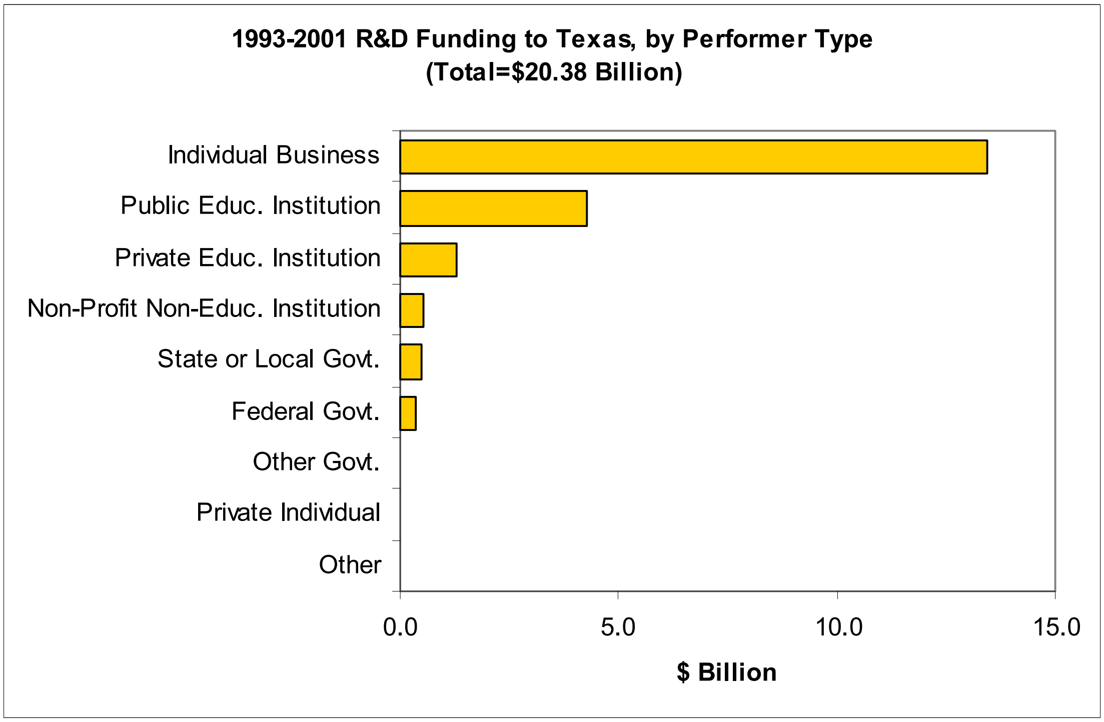


Exhibit A10

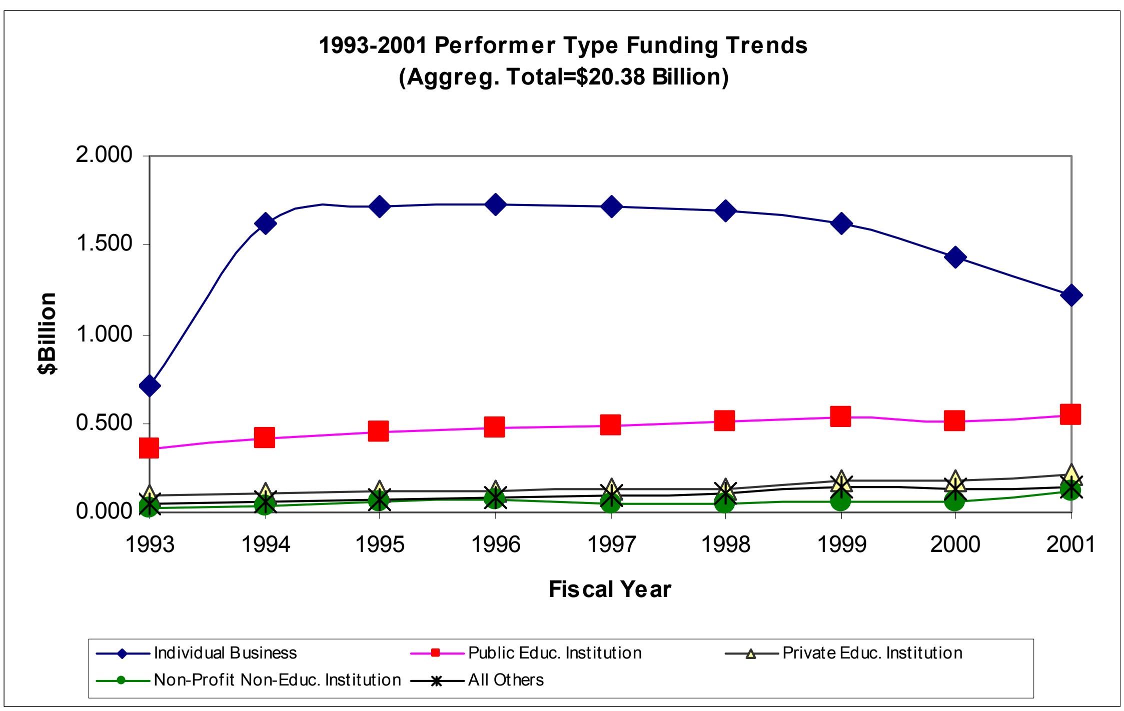


Exhibit A11

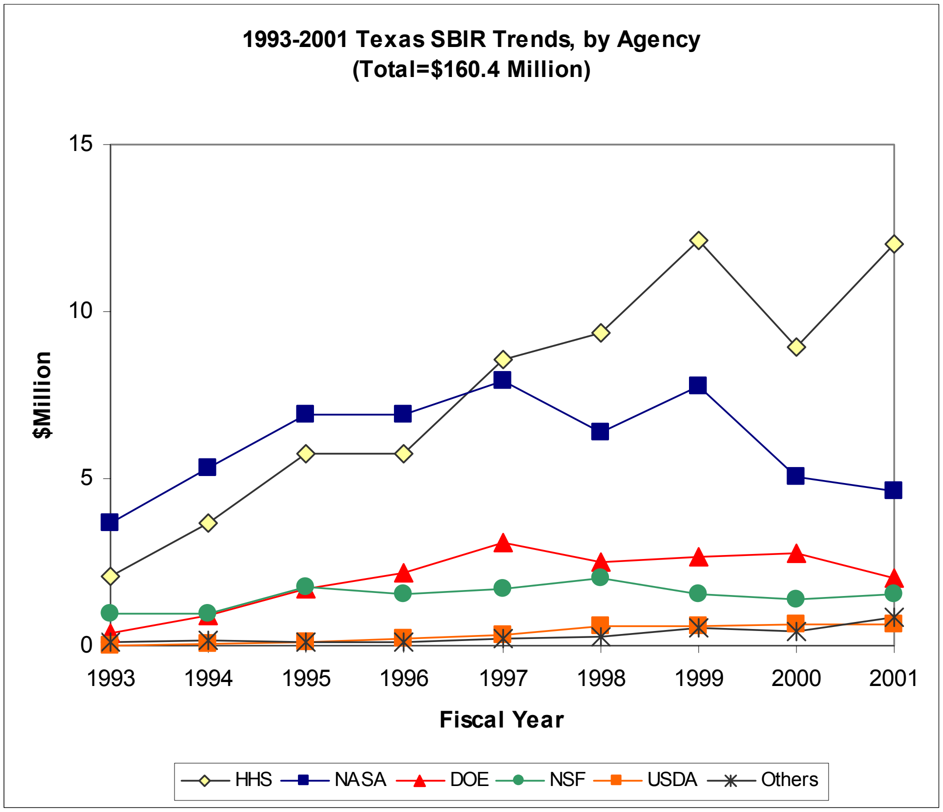


Exhibit A12

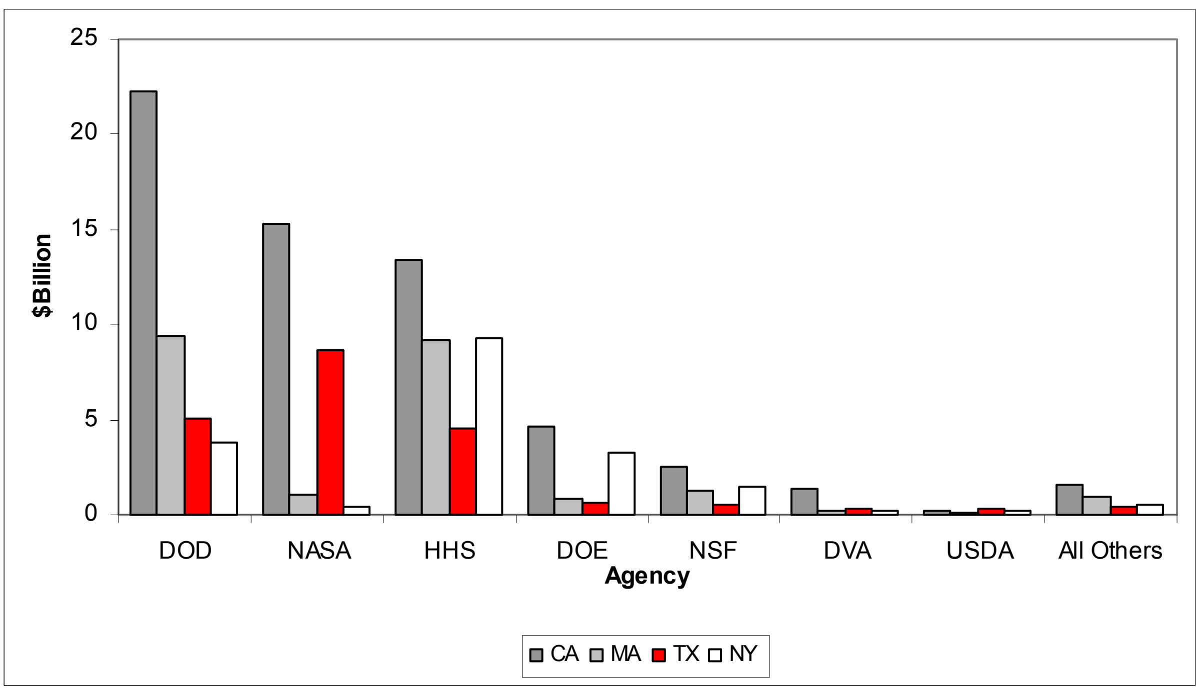


Exhibit A13

State	Number of Companies	Number of Existing Companies Started since 1975	Number of Existing Companies Started since 1990	Number of Biotech Firms	Number of Biotech Firms Started since 1975	Number of Biotechs Started since 1990
CA	518	416	269	434	353	224
GA	31	24	18	27	21	16
IN	22	16	5	18	14	5
MA	202	162	100	159	134	85
MD	122	88	54	111	81	49
MI	40	30	14	30	27	14
NC	160	127	92	114	92	66
NY	82	56	31	64	50	28
PA	85	60	37	71	54	32
TX	63	53	28	53	47	25
WA	51	43	24	43	38	21
WI	53	37	15	41	30	11

Exhibit A14

The pipeline for commercialization starts with the basic research dollar inputs at the state and federal levels. Then materializes into ideas for commercialization through patent licensing. In the first half of 2002, Texas is clearly in the hunt in the third position nationally. Note that New York has been effectively working to extract more value from its patenting process – with Columbia being the most aggressive.

Through a limited review of the 2002 Texas patents, there are early indications that life sciences are fast approaching the prime position while information technology, software, communications, mechanical devices, and traditional areas of energy and environment remain in the top sectors.

State	Patents Issued in 2001 (total 1/1/01-7/28/02)
Texas	7,724 (11,634)
California	23,229 (35,701)
Georgia	2,015 (3,000)
Indiana	1,918 (3,045)
Massachusetts	4,975 (7,537)
Michigan	4,777 (7,424)
Maryland	2,097 (3,279)
New York	8,633 (13,246)
North Carolina	2,731 (4,184)
Pennsylvania	4,992 (7,584)
Washington	2,671 (4,079)
Wisconsin	2,738 (4,112)

Exhibit A15

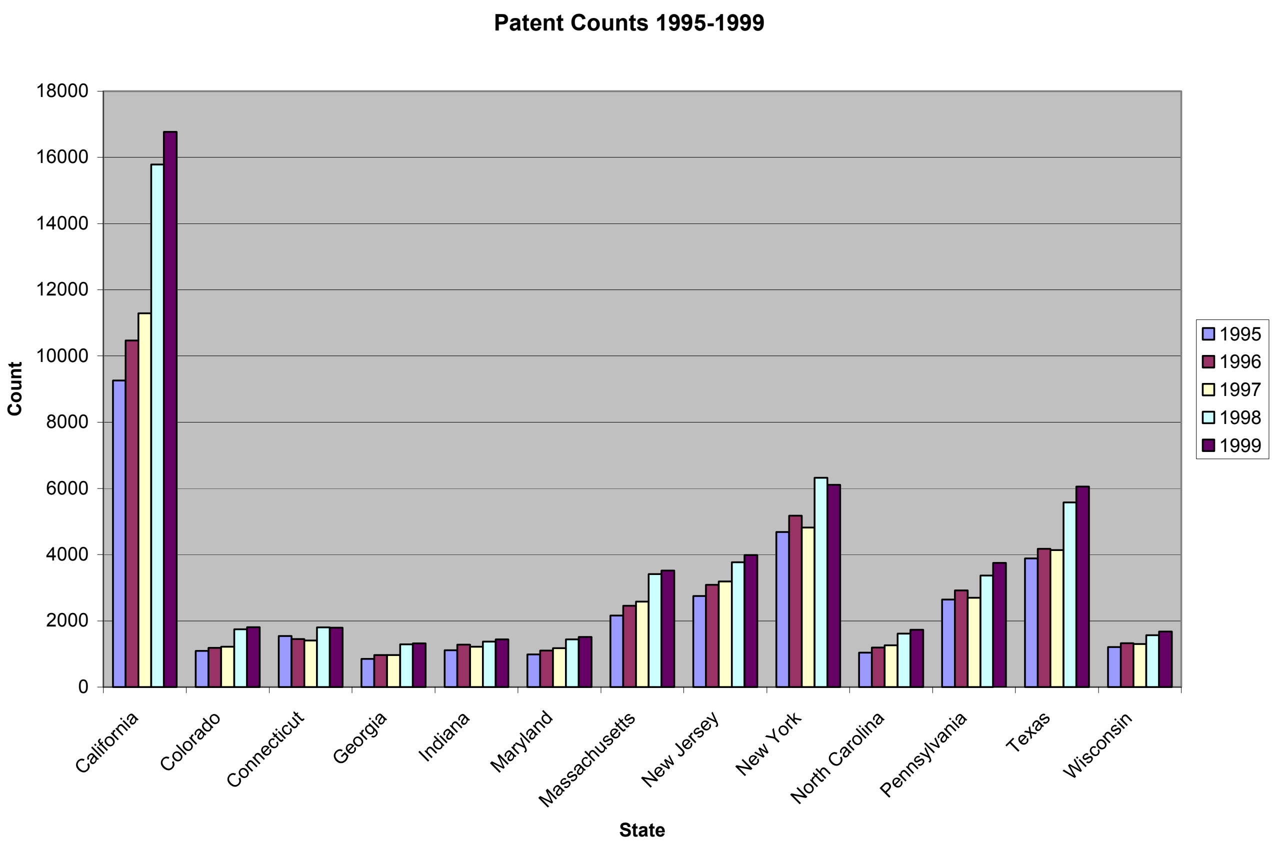


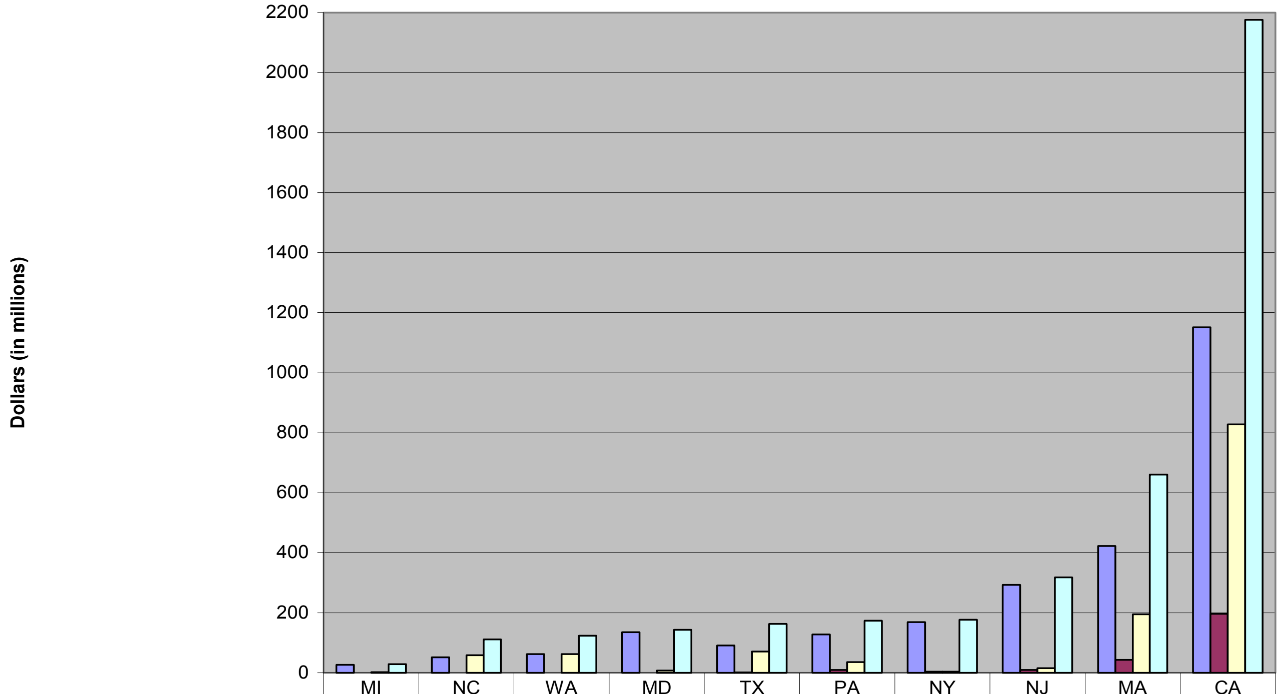
Exhibit A16

Texas Venture Capital Investment by Life Science Sector 1995-2001

	1995	1996	1997	1998	1999	2000	2001
Biotechnology - TX *	9	32	38	64	73	15	91
HealthCare Services - TX *	0	57	57	39	31	107	1
Medical Devices & Equipment - TX *	8	1	7	32	62	43	71
All Bio and Health Related - TX *	17	90	102	135	166	165	163
All VC - TX *	259	391	798	1076	2691	5747	2881
All VC - US *	5071	9640	14350	19178	52457	99625	36514
% of TX VC Funds related to Bio/Health	6.6%	23.0%	12.8%	12.5%	6.2%	2.9%	5.7%
TX Bio/Health VC Funds as a % of all US VC	0.3%	0.9%	0.7%	0.7%	0.3%	0.2%	0.4%

source: PriceWaterhouse Coopers/MoneyTree Survey

Exhibit A17

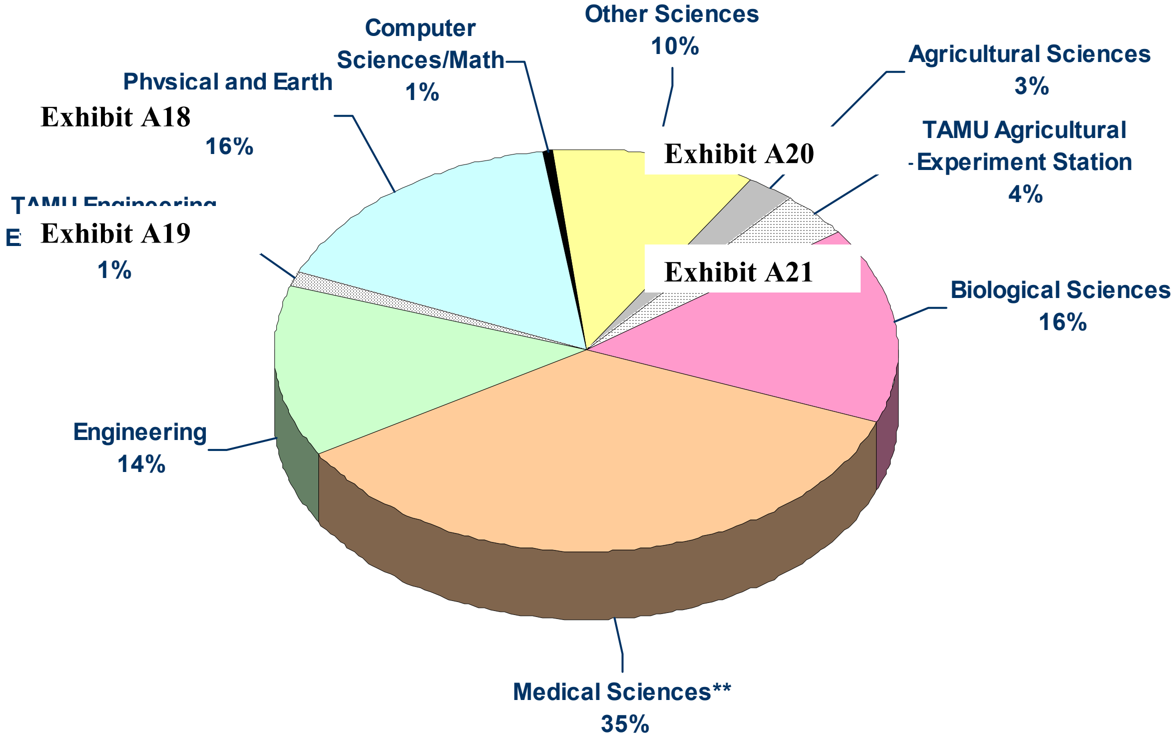


	MI	NC	WA	MD	TX	PA	NY	NJ	MA	CA
Biotechnology	27	52	62	135	91	128	169	293	423	1151
HealthCare Services	0	0	0	0	1	10	4	10	43	197
Medical Devices & Equipment	2	59	62	8	71	36	4	15	195	828
All Bio and Health Related	29	111	124	143	163	174	177	318	661	2176

Exhibit A18

Research Laboratory Space at
Texas Public and Private Universities and Health-Related Institutions*

Assignable Area in Square Feet



APPENDIX B

ETHICAL ISSUES FACING SCIENTIFIC ADVANCEMENT

The Council had only enough time to tackle issues related to scientific and economic competitiveness. Yet it recognized that general challenges beyond the scope of its charge must be identified for further consideration.

The potential benefits science offers to society are powerful incentives to support further research and development. However, the emergence of this revolutionary technology has raised a number of complex ethical questions. The following is an overview of some of the major issues being explored today.

Genetic privacy

While still in its infancy, genetic screening is beginning to change healthcare in a significant way. Knowledge about their genetic makeup and susceptibility to certain diseases can offer people greater control over their health and their future by allowing them to take preventative measures or rethink future plans, such as starting a family. Unfortunately, information about the possession of a cancer-carrying gene, for example, also may open the door to discrimination by employers or health insurance companies.

As most people are likely to have a handful of mutated genes that leave them vulnerable to certain diseases, genetic privacy has become a major issue in the United States. Congress introduced nine bills dealing with the matter in its 1999-2000 session, and four more in 2001-2002. More than one hundred bills related to genetic discrimination were introduced in state legislatures in 2000 alone.

But how should we balance the public's right to privacy and the medical community's need to conduct and share valuable research? Some contend that the same protective barriers designed to protect the individual also may prevent the flow of information, jeopardizing research, public health, emergency care and other services. In fact, patients with risk factors or diseases may *benefit* from broad public disclosure that could lead to intensified research. Some even say that absolute guarantees of privacy may be impossible, due to the flow of information from the physician's computer to the physician's office network through the Internet.

Will the privacy issues discourage patients from participating in clinical trials designed to trace gene mutations and develop treatments — slowing valuable research and the industry's ability to move forward? Can nondisclosure agreements sufficiently protect the individual? Can informed-consent agreements tell a person all he or she needs to know to make a truly informed decision? What kinds of safeguards must be implemented to assure the individual's safety from unscrupulous companies while ensuring that meaningful research can continue? As research in this area progresses, will the success of new approaches mitigate many of these problems?

Stem cell research

Stem-cell research is perhaps the hottest topic in the biotech debate. Embryonic stem cells are those unspecialized cells that appear to be able to grow into any of a variety of highly specialized cell types. To some, they hold the promise of generating new neurons for treating patients with Parkinson's disease. To others, they represent an immense threat to unborn life, a harvesting of unwanted human embryos.

This debate may soon be rendered moot; however, as recent research has revealed evidence that highly versatile stem cells can be derived from adult tissues. University of Minnesota findings suggest that stem cells derived from the bone marrow of adults may have the same versatility as their embryonic counterparts, able to develop into virtually any cell needed to repair a damaged brain, heart or other ailing organ. And they may have another advantage: the adult cells do not seem to generate spontaneous tumors, as can happen with embryonic cells.

Patenting of human genes

While the federal government banned human cloning in 2001, human genes are being cloned on a daily basis throughout the nation and the world. And genes identified as possessing specific attributes and behaviors continue to be patented. But where does one draw the line in patenting an invention? If the patent is too broad, it will face litigation. (For example, one patent filed for human gene therapy involved successful insertion of DNA into any cell under any situation.) Should patents be given for genes whose utility is not known? And should scientists be allowed to patent, for example, a gene associated with a rare disease without the donor's consent—and the opportunity to share in the profits realized from his or her donation?

When Oregon has declared DNA to be the private property of its possessor, the original intent was to prevent discrimination based on information from genetic tests. Other supporters of private ownership argue believe that corporate patents will prevent other researchers from researching tests and cures from diseases connected to that gene. Many believe that our genes are a part of nature and shouldn't be 'patentable' by anyone. They feel that religious and ethical values based on respect for life will be subverted and the concept of human rights eroded as human beings and parts of their bodies become the exclusive property of patent holders.

Researchers and private companies, by contrast, argue that one is not patenting the gene *per se*, but the information derived from that gene. Patents simply protect the investment the patent holder has made and will make to derive more useful information that can be developed into a product. In addition, they note that the genes in question are not as found in the body, but isolated, purified forms of the gene. Many assert that it's possible to protect the confidentiality of donated material without inhibiting genetic testing. Individual ownership, they say, would result in thousands of individual negotiations for each discovery, costing universities too much in legal fees and slowing research projects by years.

Public funds and private profit

After Congress passed the 1980 "Bayh-Dole Act" allowing universities to own the patents resulting from government-funded research at their facilities, universities began to seek partnerships with private partners capable of manufacturing and marketing products based on their research. This was a boon to universities, which suddenly had an opportunity to convert patents into sorely needed revenue, as well as researchers, who could now bring their innovations from the lab to practical application in the marketplace. And, of course, it was an exciting development for pharmaceutical companies and other private enterprises anxious to commercialize that research.

As a result, an unprecedented number of patents began to emerge from universities, and it is estimated that tens of billions of dollars of commercialized drugs and devices now find their beginnings in public funding.

Industry and academia claim that collaborations between colleges, pharmas, biotech companies and other research organizations move science forward much more quickly than any separate institution could do alone; that companies willing to invest millions of their own capital are rescuing research that might otherwise languish in the lab for decades.

While some have expressed concern over whether this relationship will discourage information sharing, universities and industry alike point out that no respectable university would tolerate a closed academic environment, because it is counter to their mission of knowledge dissemination. More importantly, they claim, the closer relationship between basic research and manufacturing accelerates the creation of new drugs and technologies, bringing better healthcare to the public more quickly.

Genetic engineering

As with a sonogram that tells parents whether their unborn child is a boy or a girl, genetic research may soon be able to tell us whether we are prone to certain diseases — and gene therapy ultimately may be able to fix that problem. But what will be the consequences of a society with so much knowledge and choice?

Consider the concept of designer children. Already, a Virginia-based genetics company offers couples the opportunity to choose the sex of their child for a fee. And many couples with hereditary illnesses are waiting for a time when science can help them conceive child who will be immune. Is it wrong to allow gene therapy for a fetus with the gene for Huntington's? What about the ethics of endowing it with a gene for higher intelligence or musical talent?

Those already born depend on medical science to cure our illnesses with drugs and surgery. Those in favor of genetic engineering say that it is just another technology in healthcare's medical kit, one that some day could provide the cure for Alzheimer's or cancer or diabetes. It could provide unlimited replacement organs for the thousands of people waiting in line for them, most of whom now die waiting.

But many questions remain. What about non-fatal but undesirable defects, such as albinism? And what should insurance be obligated to pay for? If a person is screened for a genetic defect such as cancer and learns she has that gene, does her employer, insurance company or even her husband have the legal right to know it? If a gene can be linked with criminal behavior, should police be allowed to keep tabs on those who possess it? Should courts allow "genetic disposition to crime" as a defense? As we manipulate genes, will we inadvertently unleash new viruses and bacteria on an unsuspecting public? And if science offers people the opportunity to live decades longer – perhaps many decades –will our economy and social systems be strained?

Genetically modified foods

Genetically modified (GM) foods are foods resulting from plants or animals whose genetic structure have been altered, generally with the goal of changing its characteristics. Such changes may enhance the organism's color, flavor, texture, ability to resist insects or ability to tolerate certain herbicides.

Comparative genomic research between animals and humans will identify genes responsible for

- Natural resistance to diseases and parasites;
- Cancer;
- Cardiovascular diseases;
- Neurological disorders;
- Reproductive health;
- Birth defects; and
- Nutrition and metabolism.

Additional research also may lead to advances benefiting both agriculture and human health, such as novel vaccines to prevent disease, therapeutics to cure disease, and nanodetection of chemical and microbial toxins.

While it is estimated that some 40 percent of food products on American shelves contain GM ingredients, concern over safety and wisdom of creating and consuming genetically modified (GM) foods has skyrocketed in recent years. In Europe, it has resulted in massive public outcries and the passage of laws banning GM foods from entering many EU countries – as well as non-GM foods once stored in the same facility as GM foods. At home, the debate over whether such foods should be labeled and how they should be regulated continues.

Most of the GM food controversy has revolved around health and environmental safety issues. GM food opponents assert that there are not enough studies are available to determine whether these food products are safe for consumption, while most of the major health care regulatory organizations in the world, including the FDA, claim there is very little risk of gene-altered foods adversely affecting humans.

Opponents say accidental cross-pollination may result in alteration and/or extinction of many pure plant species; that GM plant pollen may have adverse affects on beneficial insects; and that the creation of herbicide-resistant plants will lead to the overuse of harmful chemicals and the gradual creation of resistant "superpests" or "superweeds." They also contend that GM technology will lead to the demise of the family farm and result in global domination of the food market by a handful of large corporations.

Supporters claim that "buffer zones" eliminate most problems associated with cross-pollination. They point to overpopulation and starvation problems worldwide and this new technology's ability to produce higher yields with fewer pesticides and adapt crops to extreme soil and weather conditions. They point to other advantages as well, such as the ability to create vitamin-packed foods, foods that incorporate vaccines for easy distribution — even the ability to create fish that mature for market more quickly, providing a less expensive, high-quality food source.