ENRICHING ARIZONA'S KNOWLEDGE ECONOMY

CREATING THE RESEARCH CONNECTIONS, ATTENTION, AND TALENT ARIZONA NEEDS TO COMPETE

PROPOSITION 301 INVESTMENTS AT ARIZONA STATE UNIVERSITY

FY 2002-FY 2005

MORRISON INSTITUTE
FOR PUBLIC POLICY
ARIZONA STATE UNIVERSITY

SCHOOL OF PUBLIC AFFAIRS / COLLEGE OF PUBLIC PROGRAMS

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Morrison Institute for Public Policy

EXECUTIVE SUMMARY

Numerous studies have concluded that university science and technology research can lead to economic growth, particularly in the fast growing and high paying knowledge economy industries. Across the country and around the world, many state and national governments have heeded these studies and made substantial investments in their university research capacity. The common hope is to capitalize on the wealth and job creation that can be generated by a science and technology-based economy.

Arizona is among the biggest recent investors. Passage of Arizona's Proposition 301 in November 2000 earmarked an estimated $1 billion over 20 years to support increasing science and technology research capacity at the state's three public universities. Other research funding programs have also been initiated in the state. Now, after the first four years of Proposition 301 funding — FY 2002 through FY 2005* — the question arises: How are Arizona's Proposition 301 research investments performing?

CAT MEASURES TECHNOLOGY

This report presents results tracked by the CAT Measures, a 21st century assessment tool for enabling policymakers to monitor "en route" performance of their public investments in science and technology research. Developed by Morrison Institute for Public Policy at Arizona State University, the CAT Measures analyze growth supporting three pillars of the knowledge economy:

- **CONNECTIONS** — the networks developed among researchers, entrepreneurs, and venture capitalists that help transfer knowledge and generate economic opportunities
- **ATTENTION** — the "buzz" generated by research and research networks that attracts businesses, private investment, and highly skilled workers to a region
- **TALENT** — the top scientists, students, and technically skilled workers that help make a region fertile ground for research, innovation, entrepreneurship, and economic growth

* Arizona's fiscal year runs July 1 through June 30.

The CAT Measures are designed to augment the state's Proposition 301 investment strategy. Their purpose is to:

- track key knowledge economy impacts from state-supported science and technology research activities
- provide timely feedback to policymakers and research managers
- complement Arizona's existing measures for assessing state science and technology investments

HIGHLIGHTS OF RESULTS

In the first large-scale application of the CAT Measures to a major research investment, Morrison Institute assessed Proposition 301-related research outcomes at Arizona State University. Results reveal numerous knowledge economy impacts during the period FY 2002 - FY 2005. Some highlights of ASU's Proposition 301-supported research include:

- **CONNECTIONS** Established more than 300 contractual research connections with businesses and universities in the U.S. and abroad; engaged in over 3,400 research collaborations with professional colleagues at other institutions and companies around the world; won more than $86 million in competitive non-state public and private research grants.
- **ATTENTION** Produced over 800 scientific papers published in peer-reviewed journals; received nearly 5,300 citations of these papers in the work of researchers at other universities, labs, and companies around the world; improved ASU's ranking among top research universities by 10 percentile points.
- **TALENT** Increased the science and technology skills of 245 graduate students and postdoctoral researchers who participated directly in multidisciplinary research during FY 2005; produced science and engineering graduates whose starting salary offers increased 8 percentage points over their peers nationally.

The full range of results for ASU are presented on pages 14-15.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Although "Talent" is only one of the categories of the CAT Measures, its effects are evident in all three. Every number included in this report is fundamentally about people, what they know, or what they produce. The importance of talent to success in the knowledge economy has been recognized at the highest levels, including in the January 2006 State of the Union address, and in the president's American Competitiveness Initiative, a proposal to increase financial support for top research scientists and also improve the quality and quantity of math and science education. Three essential insights came from the research for this report:

- Hard numbers bear out the intuitive premise of Proposition 301 — that investing public money in the best and brightest university research scientists pays off *directly* in increases in external research grants, contracts, and licensing fees from intellectual property, and *indirectly* by attracting new research institutions and companies to the region.
- Arizona's past and future successes in science and technology — and subsequent economic gains — stem from how much talent is available in the region, and what is done to develop, maintain, and nurture that talent.
- Developing a robust workforce for the Arizona knowledge economy — from recruiting top research scientists and graduate students to developing the state's "pipeline" of new talent — is critical to the state's future competitiveness.

Several issues would benefit from further analysis. For example, we should know more about Arizona's labor force for the knowledge economy, including its current composition and status, and its prospects for the future, especially in regard to university and K-12 education programs. We also need more information regarding the perceptions of Arizona's students, parents, and taxpayers about science and technology and the attractiveness of these fields as careers.

These information gaps and the study's results lead to the following six recommendations for Arizona policy makers, CEOs, and education leaders:

Analyze the current and prospective labor force including Arizona's college and university students. It is time to dig below the headlines to help everyone understand exactly who comprises Arizona's talent pool and what kinds of policy choices could increase both productivity and the talent pool in science and technology.

Inventory and compare Arizona's university-based programs to increase skilled graduates — particularly among minorities — in math, science, and technology fields. While many existing programs may work well on a small scale, Arizona leaders need to understand how to boost these efforts to create a full pipeline of local talent ready with the skills required to fill the state's knowledge economy jobs, advance scientific research, and create innovative new companies.

Work with teachers and students to reinvigorate K-12 math and science teaching. For Arizona to develop a more competitive knowledge economy, K-12 teachers and students must be informed about successful Proposition 301 research efforts and the future jobs these efforts will create in Arizona. Teachers and students also need new incentives to upgrade their science and technology skills and credentials.

Assess Arizonan's attitudes toward science and technology, particularly the perceived benefits or drawbacks for themselves, for Arizona students, and for the economy. Such information could help improve K-12 and postsecondary education and lead to new strategies for increasing the state's future talent pool for a knowledge economy.

Determine why some research initiatives pay off better for the knowledge economy than others. Conduct in-depth analyses of exemplary research projects and teams to uncover the reasons behind their steep trajectories; then create an accounting of "best practices" for use in planning and guiding future research investments.

Answer the question: "Is Arizona becoming more competitive in the national and global knowledge economy?" Convene a roundtable group of internationally prominent analysts to periodically review relevant data and determine how Arizona's research trajectory compares with those of acknowledged research leaders elsewhere in the world.

SCIENCE AND TECHNOLOGY RESEARCH AS AN ECONOMIC DEVELOPMENT STRATEGY: DOES IT WORK?

In 2000, the value of university research grant funding in the U.S. from all sources — federal, industrial, state, and others — exceeded $30 billion, the highest in the world. Arizona universities, however, received only a small share of those funds, attracting less than half a billion dollars, or about 1.3% of the nation's total.

But 2000 proved to be a watershed year for science and technology research at Arizona's universities. In November 2000, Arizona voters approved a legislatively referred ballot measure that established a special state sales tax dedicated to educational purposes. This vote for education included a large and unprecedented new investment in science and technology research at Arizona's three public universities: Arizona State University, University of Arizona, and Northern Arizona University. The goal of the research investment was to:

- increase Arizona's share of "external" funding (e.g., federal and industrial grants) for university science and technology research
- stimulate growth of the state's knowledge economy (companies that rely on science and technology expertise)
- attract and train more top scientists, engineers, and skilled knowledge workers
- generate more high-paying jobs for Arizona residents

Numerous studies have made the case that the amount of money a country or region spends on research funding correlates strongly with the region's long-term economic growth. That is why across the country and around the world, governments rich and poor expect to capitalize on the wealth and job creation that can be generated by a science and technology-based economy. Already in the U.S., many state governments have made substantial investments to increase the research capacity of their public universities.

Although the Proposition 301 funds earmarked for Arizona's universities — almost $50 million per year, nearly $1 billion over 20 years — may seem like a huge investment, it is actually small compared to the amount of federal, industrial, and other grant funds that universities must additionally win in order to become competitive research institutions. Thus, the real purpose of state research investments is to create conditions at the universities that will attract and generate new funding in multiples of what the state spends. Only then can research outputs be substantial enough to produce noticeable economic results over time.

So a legitimate question arises: Is Arizona's new emphasis on science and technology research actually working as an economic driver? One thing is clear. Arizona universities have increased their total university grant funding since 2000. From 2001 (when Proposition 301 revenue started to be collected) to 2003 (the most recent National Science Foundation data available), Arizona's total *external* research funding* increased by $90 million, or 28%. This increase was almost 11 percentage points higher than Arizona's performance for the period 1998 to 2000, and 4 percentage points higher than the national average increase. Nevertheless, it represents only a small increase in Arizona's national share to 1.4%.

But grant funding growth is only one indicator of success for the state's strategy. Moreover, it is not clear how much, if any, of the above results are due to a single targeted investment such as Proposition 301. To better understand the impacts of the Proposition 301 research investment by itself, one must consider what Proposition 301 funding is intended to do: enable Arizona's public universities to conduct research that leads to new products, new companies, new higher-paying jobs, and a virtuous cycle of economic growth. To achieve

* These were grants won by Arizona university scientists from federal, industrial, and other non-state sources to support proposed or expanded research projects.

these goals, the universities will need to apply their new funding to hire and retain more top researchers; train future highly-sought scientists and skilled graduates to work in Arizona businesses; establish beneficial networks of shared knowledge with researchers at other institutions and companies; and build a reputation for Arizona as fertile ground for innovation, research, and opportunity. These are not short-term strategies with immediate gratification. It will take time to accomplish all of these tasks…decades at least.

In the meantime, Arizonans need an assessment tool to help them decide whether their public investments in university science and technology research are on the right track. The solution is similar to that used for any investment in long-term returns. The Proposition 301 investment must be monitored "en route" to its ultimate goal of strengthening Arizona's knowledge economy. Regular assessment will help policymakers and research managers analyze whether the funded research has taken a promising direction, and it will help them track whether it stays on course year after year. Such assessments can't guarantee success, but if applied fairly and used wisely, they can aid in decision-making and "course corrections," thereby increasing the odds that investment money will be put where it does the most good. Moreover, good assessments offer a far better strategy than just waiting and hoping for progress. The problem is that no such assessments have previously been available.

The report that follows presents the CAT Measures, a 21st century assessment tool for policymakers that enables en route monitoring of public investment in science and technology research. Developed by Morrison Institute for Public Policy at Arizona State University, the CAT Measures track growth supporting three critical pillars of the knowledge economy: Connections, Attention, and Talent (see page 11 for more information).

In this, the first large-scale application of the CAT Measures to a major research investment, Morrison Institute has assessed Arizona State University's Proposition 301-related research outcomes. Results for the first four years of Proposition 301 funding are presented on subsequent pages. In addition, two appendices contain background information and complementary results regarding the Proposition 301 investment at ASU. These appendices include an overview of Proposition 301 funded research projects and data from ASU's report on performance measures required by the Arizona Board of Regents.

The data are here. But what is the multiplier effect for Arizona's economy when ASU's Proposition 301-funded research annually produces 200 new scientific papers, educates 250 new scientists, or attracts $28 million worth of new grants? Connecting these accomplishments to Arizona's economic prosperity requires additional research and a longer period of data collection. Nevertheless, economists and economic developers increasingly agree that an area with top talent, closely linked networks of researchers, and continuously generated new ideas has a powerful competitive advantage.

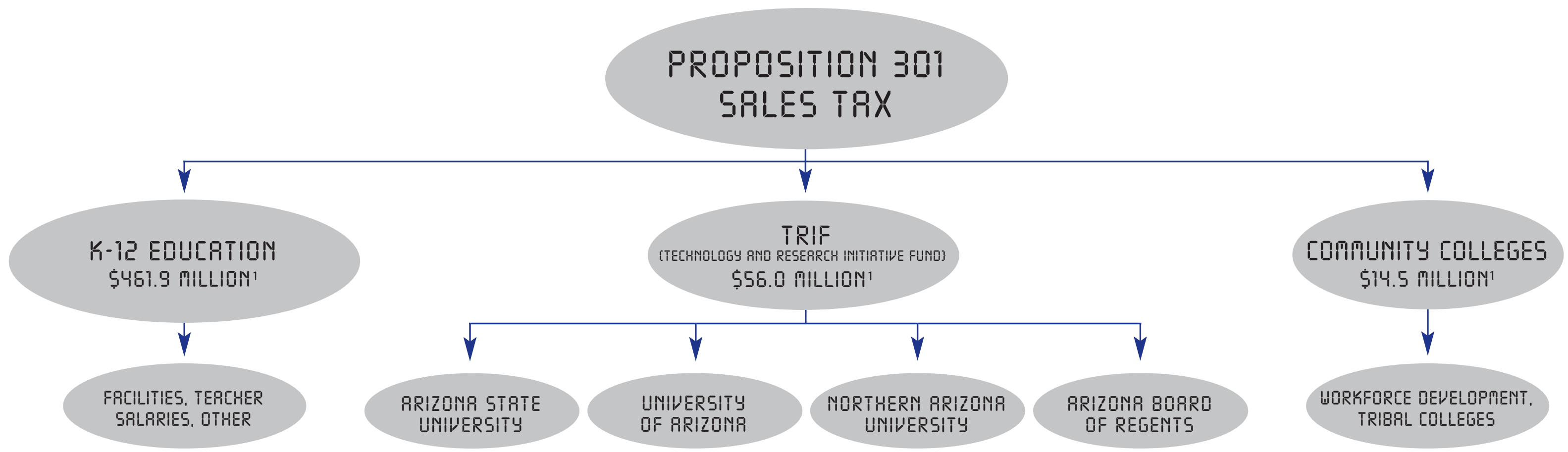
The research results contained in this report paint a picture of how well the Proposition 301 funding has been leveraged by ASU and how much it has contributed to the state's knowledge economy. Such knowledge can help policymakers and research managers grasp the direction these investments have taken, the intensity of the research output, and the assets for success that have been created. With continued monitoring and analysis, the forecasts should keep getting better.

ABOUT PROPOSITION 301 AND ARIZONA'S TECHNOLOGY AND RESEARCH INITIATIVE FUND

Arizona Proposition 301 was a ballot measure conceived by state leaders to provide financial support to specific statewide education programs. It was referred to the ballot by the Arizona State Legislature and approved by voters in November 2000. Among it's features:

- Proposition 301 established a 20-year-long, 0.6% increase in state sales taxes primarily to support K-12 education programs, public university science and technology research, and community college workforce development programs.
- The Proposition 301 sales tax produced over $532 million for all beneficiaries in fiscal year 2005 (FY 2005 runs July 1, 2004 to June 30, 2005).
- The public university share of Proposition 301 revenue for FY 2005 totaled almost $56 million, which was allocated among Arizona's three public universities and the Arizona Board of Regents. The university share is anticipated to cumulatively reach $1 billion by FY 2021.
- Revenue from Proposition 301 for the state's three public universities flows through "TRIF," the state's Technology and Research Initiative Fund, which is administered by the Arizona Board of Regents as part of a long-term economic development strategy for the state.
- The goal of the Proposition 301 investment in Arizona's public universities is to build the state's science and technology portfolio to provide both a foundation for, and stimulus to, a competitive knowledge economy in Arizona.

SIMPLIFIED DISTRIBUTION OF PROPOSITION 301 REVENUE



Source: Morrison Institute for Public Policy, 2006.

[1] FY 2005.

ASU'S RESEARCH REVENUE AND EXPENDITURES FROM PROPOSITION 301

ASU's new research revenue from Proposition 301 amounted to $18.7 million in FY 2005. Over the four fiscal years, FY 2002 through FY 2005, Proposition 301 provided a total of $64.8 million for ASU research.* These funds were assigned to research related activities each year as follows:

- **FY 2002** Six independent research and support initiatives in biosciences, information technology, advanced materials, manufacturing, technology transfer, and access/workforce development
- **FY 2003 through FY 2005** Large interdisciplinary research projects under the Biodesign Institute at ASU and ASU's Capacity Building Project Investments (see Appendix A for more information)

ASU's expenditures of Proposition 301 revenue for research and support initiatives totalled $20.3 million in FY 2005, including unspent funds from the prior year. Expeditures were:

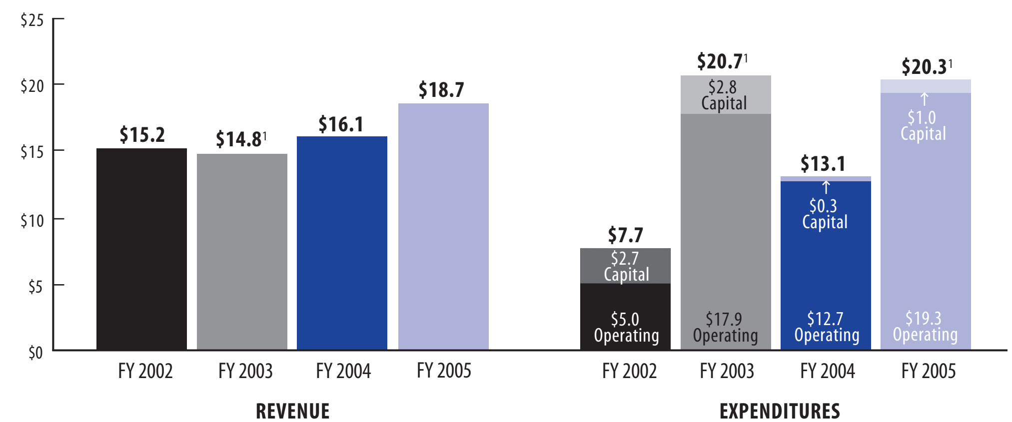
- $19.3 million for operating expenses
- $1.0 million for capital expenses related to Proposition 301 research projects

Over the four fiscal years FY 2002 through FY 2005, ASU expenditures totaled $61.8 million for Proposition 301-related research and research support initiatives.

* Financial data do not include Proposition 301 funds allocated to ASU Polytechnic and ASU West for capital infrastructure development and building and central plant expansion.

ASU PROPOSITION 301 REVENUES AND EXPENDITURES FOR RESEARCH ($ MILLIONS)

	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005	TOTAL FY 2002-FY 2005
New Revenue	$15.2	$14.8	$16.1	$18.7	$64.8
Expenditures	$7.7	$20.7[1]	$13.1	$20.3[1]	$61.8
Operating	$5.0	$17.9	$12.7	$19.3	$54.9
Capital	$2.7	$2.8	$0.3	$1.0	$6.8



Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* Arizona Board of Regents for fiscal years 2002, 2003, 2004 and 2005.

Note: Figures may not sum due to rounding.

[1] Expenditures exceed revenue in some years because unspent funds from prior years were carried forward.

ASU ACCOUNTABILITY AND ANALYSIS OF PROPOSITION 301 RESEARCH

Research and fiscal results from Proposition 301 funding at Arizona's public universities have been regularly monitored and reported since FY 2002.

- **Annual TRIF reports** The Arizona Board of Regents requires Arizona's three public universities to collect data annually on specific performance measures for Proposition 301-supported research. Results each year are compiled in an annual Technology and Research Initiative Fund report* that is reviewed by the Arizona Board of Regents in August, and then presented to the Governor of Arizona and the Arizona Legislature in September.
- **Three-Year Aggregate Report** At the end of FY 2004, the Board of Regents required universities to submit a special report aggregating results from the first three years of Proposition 301 funding. For ASU, that information was provided by Morrison Institute (see below).
- **Annual Morrison Institute reports** Since 2002, Morrison Institute for Public Policy has been conducting ongoing, value-added analysis of ASU's performance that is in addition to reporting required by the Board of Regents.
  - Morrison Institute's FY 2002 report, *Seeds of Prosperity: Public Investment in Science and Technology Research**, described ASU's first-year Proposition 301-supported activities, presented ASU's Proposition 301 results in light of current thinking on the knowledge economy, explained the economic and industrial context for ASU's high tech research, and introduced the concept of the CAT Measures — a new model for determining public return from state investment in university-based science and technology research by analyzing the value of Connections, Attention, and Talent (see page 11 for more information).
  - Morrison Institute's FY 2003 report, *New Returns on Investment in the Knowledge Economy: Proposition 301 at Arizona State University, FY 2003**, analyzed data from the August 2003 ASU report to the Arizona Board of Regents and presented ASU's performance relative to the knowledge economy in five categories: new money, new programs, new ventures, new skills, and new talent.
  - Morrison Institute's FY 2004 report, *New Returns on Investment in the Knowledge Economy: Proposition 301 at Arizona State University; Three-year Aggregate Report, FY 2002 - FY 2004**, compiled and analyzed ASU performance measures over the first three years of Proposition 301 funding, presented return on investment data relevant to the knowledge economy, and illustrated performance trends over the three years.
  - Since FY 2002, Morrison Institute researchers have been developing the CAT Measures, a new assessment tool for analyzing the performance of investments made in university science and technology research for economic development purposes. In 2004, a field test of the CAT Measures was conducted assessing the Biodesign Institute at ASU.

* Links to these reports can be found on page 20.

ABOUT THE CAT MEASURES ASSESSMENT OF SCIENCE AND TECHNOLOGY RESEARCH

The purpose of the CAT Measures assessment tool is to:

- track key knowledge economy impacts from state-supported science and technology research activities
- provide timely feedback to policymakers and research managers
- complement Arizona's existing measures for assessing state science and technology investments

In keeping with the state's Proposition 301 investment strategy, the CAT Measures focus on research outcomes related to three pillars of the knowledge economy considered critical to the innovation and technological advance that feeds knowledge economy growth. These pillars have not previously been tracked in a systematic and timely manner. They are:

- **CONNECTIONS** — the networks developed among researchers, entrepreneurs, and venture capitalists that help transfer knowledge and generate economic opportunities
- **ATTENTION** — the notice generated by research and research networks that attracts businesses, private investment, and highly skilled workers to a region
- **TALENT** — the top scientists, students, and technically skilled workers in a region that help make it fertile ground for research, innovation, entrepreneurship, and economic growth

The following page displays the array of CAT Measures with corresponding units of analysis, data sources, and explanations. For 12 of the 15 indicators, data are based on output from the total group of researchers ("Prop 301 cohort") involved with Proposition 301-related projects at ASU during FY 2005. Two indicators — both rankings — are based on the performance of the university as a whole. One indicator — salary offers — focuses only on science and engineering graduates with majors related to Proposition 301 topics (e.g., molecular biology, bioengineering).

CAT MEASURES, UNITS OF ANALYSIS, AND DATA SOURCES

INDICATOR	UNIT/COHORT	DATA SOURCE	DESCRIPTION
CONNECTIONS – Increase interactions and relationships with science and technology investors and innovators			
1. New research grants/contributions from federal sources	Prop 301 cohort[1]	ORSPA database[3]	Nominal amount of new federal grant funds won in a given fiscal year
2. New research grants/contributions from private sources	Prop 301 cohort[1]	ORSPA database[3]	Nominal amount of all other non-state grant funds won in a given fiscal year
3. Commitments to research consortia/agreements	Prop 301 cohort[1]	ORSPA database[3]	Number of research contracts between ASU and other institutions or companies
4. Non-ASU coauthors for published papers	Prop 301 cohort[1]	Thomson Scientific database of articles	Number of non-ASU researchers who co-authored a Prop 301 cohort published paper in a given year
5. Income from licenses and royalties on patents	Prop 301 cohort[1]	Arizona Technology Enterprises	Dollar amount of fees generated from inventions by cohort members
ATTENTION – Improve public and private sector perceptions of ASU science and technology research			
6. Published papers by researchers	Prop 301 cohort[1]	Thomson Scientific database of articles	Number of unique published papers for the cohort in recognized journals
7. Citations by non-ASU researchers of published papers	Prop 301 cohort[1]	Thomson Scientific database of articles	Number of times the Prop 301 cohort's papers have been cited in other papers in a given year
8. Visiting faculty and researchers	Prop 301 cohort[1]	OVPREA[4] survey of researchers	Number of visiting faculty and researchers formally participating in Proposition 301 research at ASU
9. Performance ranking among top research universities (as percentile)	ASU	Top American Research Universities (TheCenter)	ASU ranking averaged within tier and converted to percentile
10. Ranking among best national universities (as percentile)	ASU	America's Best Colleges (US News & World Report)	ASU ranking weighted within tier by peer assessment and converted to percentile
TALENT – Increase the quality of the science and technology workforce at ASU and in Arizona			
11. Total faculty-level researchers	Prop 301 cohort[1]	OVPREA[4] survey of researchers	Number of faculty-level researchers in Proposition 301 research centers or groups
12. Total post-doctoral researchers	Prop 301 cohort[1]	OVPREA[4] survey of researchers	Number of post-doctoral researchers participating in Proposition 301 research centers or groups
13. Total graduate students	Prop 301 cohort[1]	OVPREA[4] survey of researchers	Number of graduate students participating in Proposition 301 research centers or groups
14. Salary comparisons for recently degreed graduate students	Selected ASU, national graduates[2]	ASU Career Services, NACE[5] salary surveys	Starting salary offers reported in surveys of recent graduate students at ASU and nationally with majors related to Proposition 301 areas
15. Researchers with major honors	Prop 301 cohort[1]	U.S. National Academies, U.K. Royal Society	Number of researchers with membership in one of the U.S. National Academies or the U.K. Royal Society

Source: Morrison Institute for Public Policy, 2005.

[1] All ASU faculty-level researchers affiliated with Proposition 301-related research centers and groups during FY 2005.

[2] Science and engineering graduates with masters or doctoral degrees related to Proposition 301 topics (e.g., molecular biology, bioengineering) who responded to Career Services survey of graduates.

[3] ORSPA: Office of Research and Sponsored Projects Administration at ASU.

[4] OVPREA: Office of Vice President for Research and Economic Affairs at ASU.

[5] NACE: National Association of Colleges and Employers.

HIGHLIGHTS OF ASU'S PROPOSITION 301 RESEARCH IMPACTS FOR THE KNOWLEDGE ECONOMY

Application of the CAT Measures reveals numerous knowledge economy impacts from Proposition 301-supported research at ASU from FY 2002 - FY 2005*. Some highlights of these research results include:

- **CONNECTIONS** Established more than 300 contractual research connections with businesses and universities in the U.S. and abroad; engaged in over 3,400 research collaborations with professional colleagues at other institutions and companies around the world; won more than $86 million in competitive non-state public and private research grants.
- **ATTENTION** Produced over 800 scientific papers published in peer-reviewed journals; received nearly 5,300 citations of these papers in the work of researchers at other universities, labs, and companies around the world; improved ASU's ranking among top research universities by 10 percentile points.
- **TALENT** Increased the science and technology skills of 245 graduate students and postdoctoral researchers who participated directly in multidisciplinary research during FY 2005; produced science and engineering graduates whose starting salary offers increased 8 percentage points over their peers nationally.

The full range of results for ASU are presented on the following pages.

* In FY 2005, for the first time, the CAT Measures were used to assess the full range of Proposition 301-supported research at ASU. To the extent possible, data were collected for the five most recent fiscal years, FY 2001 through FY 2005. This period includes the first four years of Proposition 301 funding (FY 2002 - FY 2005), plus a "baseline" year (FY 2001) for comparison purposes. Four of the 15 indicators had data available for FY 2005 only.

ASU PROPOSITION 301 RESEARCH OUTCOMES: FIFTEEN INDICATORS OF PROGRESS FOR THE KNOWLEDGE ECONOMY

CAT MEASURES INDICATOR	BASELINE FY 2001	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005	TOTAL YEARS 1-4	CHANGE FY 2005 vs. FY 2001
CONNECTIONS – Increase interactions and relationships with science and technology investors and innovators							
1. New research grants/contributions from federal sources	$8.2M	$11.0M	$14.4M	$19.6M	$21.7M	$66.7M	+$13.5M
2. New research grants/contributions from private sources	$2.8M	$3.7M	$4.4M	$5.3M	$6.6M	$20.0M	+$3.8M
3. Commitments to research consortia/agreements	50	58	73	81	103	315	+53
4. Non-ASU coauthors for published papers	312	644	786	1,020	976	3,426	664
5. Income from licenses and royalties on patents	$68K	$69K	$77K	$78K	$893K	$1.1M	+$825K
ATTENTION – Improve public and private sector perceptions of ASU science and technology research							
6. Papers published by researchers	126	152	197	244	231	824	+105
7. Citations by non-ASU researchers of published papers	15	226	813	1,822	2,432	5,293	+2,417
8. Visiting faculty and researchers	*	*	*	*	10	–	–
9. Performance ranking among top research universities (as percentile[1])	47th	52nd	59th	62nd	57th	–	+10
10. Ranking among best national universities (as percentile[1])	48th	48th	49th	48th	50th	–	+2
TALENT – Increase the quality of the science and technology workforce at ASU and in Arizona							
11. Total faculty-level researchers	*	*	*	*	171	–	–
12. Total post-doctoral researchers	*	*	*	*	66	–	–
13. Total graduate students	*	*	*	*	179	–	–
14. Salaries of recently degreed graduate students (as % of national salaries)	95%	93%	76%	90%	103%	–	+8%
15. Researchers with major honors	1	1	2	2	4	–	+3

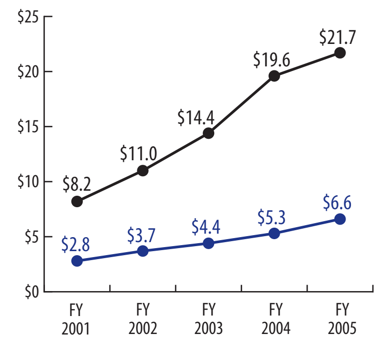
Source: Morrison Institute for Public Policy, 2005.

Symbols: * data not available; – not applicable.

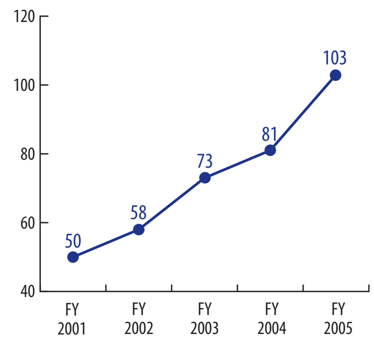
[1] Percentile: a scale of 1 to 99 in which higher is better and 50 is exactly average.

TRAJECTORY: CONNECTIONS, ATTENTION, AND TALENT ATTRACTED BY PROPOSITION 301 RESEARCH AT ASU

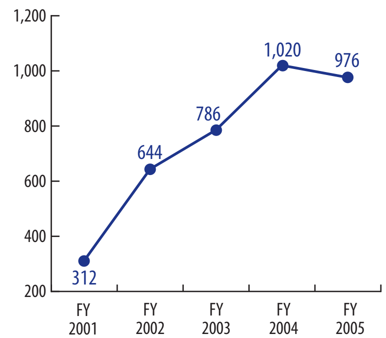
NEW RESEARCH GRANTS/CONTRIBUTIONS FROM FEDERAL (•) AND PRIVATE (•) SOURCES
In Millions of Dollars



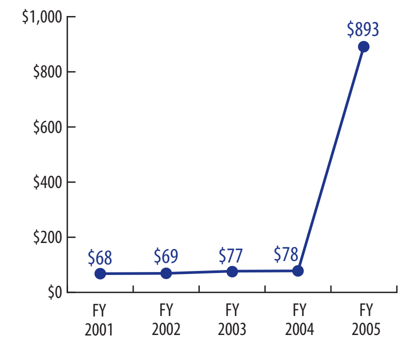
COMMITMENT TO RESEARCH CONSORTIA/AGREEMENTS



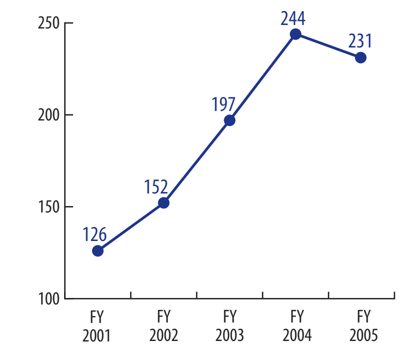
NON-ASU COAUTHORS FOR PUBLISHED PAPERS



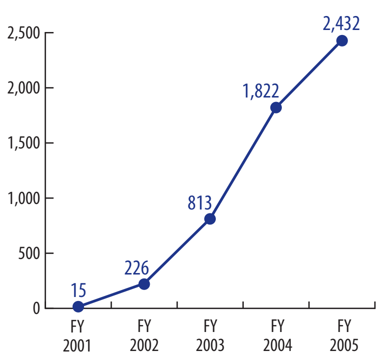
INCOME FROM LICENSES AND ROYALTIES ON PATENTS
In Thousands of Dollars



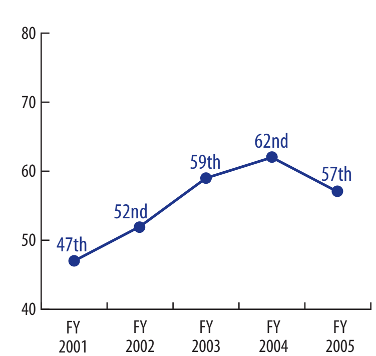
PAPERS PUBLISHED BY RESEARCHERS



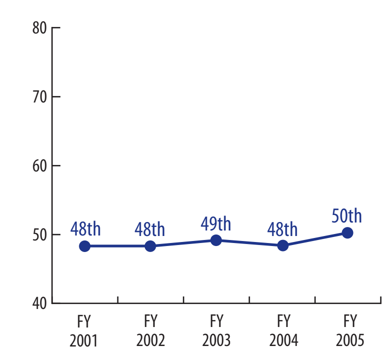
CITATIONS BY NON-ASU RESEARCHERS OF PUBLISHED PAPERS



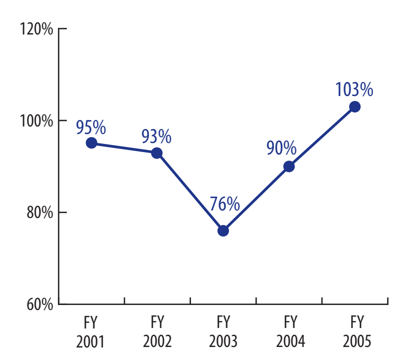
PERFORMANCE RANKING AMONG TOP RESEARCH UNIVERSITIES
As a Percentile[1]



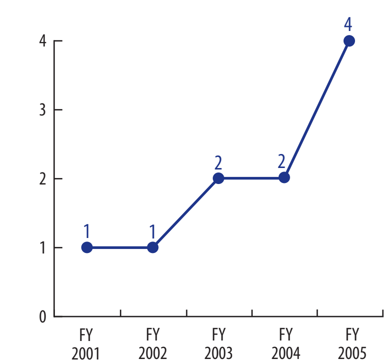
RANKING AMONG BEST NATIONAL UNIVERSITIES
As a Percentile[1]



SALARIES OF RECENTLY DEGREED GRADUATE STUDENTS
As a Percent of National Salaries



RESEARCHERS WITH MAJOR HONORS



Source: Morrison Institute for Public Policy, 2005.

[1] Percentile: a scale of 1 to 99 in which higher is better and 50 is exactly average.

INTERPRETING RESULTS: WHAT DO THE CAT MEASURES TELL US SO FAR?

The CAT Measures reveal an encouraging performance for ASU's portfolio of Proposition 301-supported research projects during the first four years of funding, FY 2002 through FY 2005. Indicators of Connections and Attention show especially strong results. Data available for the Talent indicators are also positive; however, some Talent indicators lack complete historic data for comparison over time. Specific interpretation for each category of the CAT Measures follows.

CONNECTIONS All five indicators of Connections show substantial growth over the baseline year, as well as fairly steady growth from one year to the next. Three of the indicators — research grants from both federal and private sources and commitments to consortia — more than doubled over the period. A fourth indicator, external coauthors, did even better, more than tripling despite a slight decline from Year 3 to Year 4. Most remarkable, the indicator for income from licenses and royalties increased by 13-fold. This is mainly attributed to payments made by two companies for ASU patents in Year 4.

ATTENTION Four of the five indicators of Attention have multi-year data for comparison purposes. All four produced increases over the baseline year. Specifically, published papers approached a doubling of the baseline number in Year 3, but then dropped back a small amount for Year 4. The number of citations of those papers by outside researchers, however, grew steadily and dramatically straight through Year 4. Ranking among top research universities increased by 15 percentile points as of Year 3, but then fell off by five points in Year 4 to a 10 percentile increase over the baseline. Ranking by national universities in the U.S. held fairly steady across all years, but moved two percentile higher in Year 4. No baseline or Year 1-3 data were available for visiting faculty and researchers.

TALENT Only two indicators of Talent have comparable multi-year data available. Both showed increases over the baseline year. First, recent graduate students in Proposition 301 research fields saw their starting salary offers increase over their peers nationally despite a large unexplained dip in Year 2. Second, the number of researchers with major honors (e.g., membership in the prestigious National Academy of Science), increased from one to four, due entirely to ASU's successful recruitment of eminent scientists to campus. Since internationally prestigious scientists are aggressively recruited by universities, corporations, and even nations, a gain of three in this category is significant, and demonstrates how important Proposition 301 funding has been in making Arizona competitive in attracting top quality, sought-after researchers. The three indicators for research participants (faculty-level researchers, post-doctoral researchers, and total graduate students) had no complete data available for prior years, but records from some research units and anecdotal information indicate that each of these areas has also seen substantial increases.

The CAT Measures picture will become richer and the trends more revealing as time passes. This will occur, not only because additional years of data will be available, but also because the CAT Measures assessment is designed to employ a mix of metrics that represent different stages of research output. Some indicators are more likely to produce results early, while others will accelerate later, if and when the research bears fruit.

Research staffing level is an example of an early-stage indicator. For most new research initiatives, money flows first into recruitment efforts that attract new faculty, post-docs, and graduate students to the research agenda, as well as into new facilities that provide the capacity to undertake the research. Staffing indicators, therefore, are more likely to jump quickly during the first years of funding if recruitment is successful, but then flatten their trajectory when research teams have reached optimum size. Likewise, growth in the number of new papers published will tend to follow staffing increases, and then level off somewhat. On the other hand, citations of research papers can continue to grow if the discoveries and new technologies described are of particular interest or utility to researchers elsewhere. Therefore, the trajectory of citations may give insight about the quality of the research being conducted.

University rankings are an example of late-stage indicators. Both rankings used in the CAT Measures rely on a variety of data sets that — due to the time it takes to gather data and publish them — always reflect a time behind "right now." The rankings also include outside perceptions of the university, and reputations can take a substantial time to change, up or down. The licensing and royalties measure is another late-stage indicator. This metric is directly related to inventions that have received industry interest and new companies that have spun off from the research. These are among the ultimate outputs of university-based research, and would be expected to grow most strongly during later stages of research as efforts mature, patents are approved, and innovations are successfully bundled together and marketed.

What, then, explains the huge spike in licensing revenue that occurred in Year 4? This spike reflects the fruits of earlier research nearing completion when Proposition 301 funding began to flow. Should this, then, "count" as a Proposition 301-related research result? Yes. New research initiatives are rarely designed to be conducted in isolation from the past, nor from research being conducted around the world. To the contrary, they build on the existing research strengths of an institution and seek to expand these strengths into new territory. For Proposition 301-related research at ASU, the extra funding and support for technology transfer helped existing research projects move out the door more quickly with new inventions and products, thereby allowing research teams to move on to further advances. As a result, licensing and royalties have already accrued in the early years, though not to the extent anticipated in years to come.

POLICY RECOMMENDATIONS

The CAT Measures track three categories of en route indicators — Connections, Attention, and Talent. Each is vitally important for reaching Proposition 301's goal of generating lasting economic return. Of the three measures, however, the Talent category drives the rest in building a knowledge economy. Every CAT Measures number included in this report is fundamentally about talented people, what they know, and the valuable types of knowledge they produce.

The importance of talent to success in the knowledge economy has been recognized at the highest levels. President Bush, in his January 2006 State of the Union address, echoed many when he said: "To keep America competitive…we must continue to lead the world in human talent and creativity." He then introduced the American Competitiveness Initiative, a proposal that would increase financial support for top research scientists and improve the quality and quantity of math and science education.

For Arizona, the research for this first full CAT Measures report has produced the following essential insights regarding talent:

- Hard numbers bear out the intuitive premise of Proposition 301 — that investing public money in the best and brightest university research scientists pays off *directly* through increases in external research grants, contracts, and licensing fees from intellectual property; and *indirectly* by attracting new research institutions and companies to the region.
- Arizona's past and future successes in science and technology — and subsequent economic gains — stem from how much talent is available in the region, and what is done to attract, maintain, and nurture that talent.
- Developing a robust workforce for the Arizona knowledge economy — from recruiting top research scientists and graduate students to increasing the state's "pipeline" of new talent — is critical to the state's future competitiveness.

The CAT Measures provide valuable feedback on Arizona's progress in developing talent for the knowledge economy, but they only tell part of the story. More information should be developed. For example, Arizona's labor force has not been sufficiently analyzed in recent years. No one has unlocked the reason why certain students take math and science classes or how they make science and engineering career choices. Not enough is known about how Arizona's students, parents, and taxpayers perceive advances in science and technology or why these fields continue to be such a tough sell to students. And Arizona still needs to find a way to measure the state's progress against the rest of the world.

These information gaps and the study's results lead to the following six recommendations for Arizona policymakers, CEOs, and education leaders:

Analyze the current and prospective labor force including Arizona's college and university students. For decades, business, education, and government leaders have publicly committed to creating a quality workforce. But beyond basic demographics and broad generalities, few know its composition today, how it is changing for the future, or how to make it more productive for the innovation-driven economy that Arizona leaders want to create. It is time to dig below the headlines to help everyone understand exactly who comprises Arizona's talent pool and what kinds of policy choices could increase both productivity and the talent pool in science and technology.

Inventory and compare Arizona's university-based programs to further increase skilled graduates — particularly among minorities — in math, science, and technology fields. Arizona's universities should increase the number of in-state students who attain degrees in technical fields such as math, science, and engineering. The question is, how? A critical look at the state's myriad programs would be a good starting point. While many programs may work well on a small scale, Arizona leaders need to understand how to boost these efforts to create a full pipeline of local talent ready with the skills required to fill the state's knowledge economy jobs, advance scientific research, and create innovative new companies.

Work with teachers and students to reinvigorate K-12 math and science teaching. This topic has been in the news for decades, but Arizona has not yet figured out how to include everyone in math and science achievement or careers, especially minority students. While some progress has been made, much more impact on this issue is necessary if Arizona is to become more competitive in the knowledge economy. K-12 teachers and students must be informed about successful Proposition 301 research results and the future jobs these efforts will create in Arizona. Teachers and students also need new incentives to upgrade their science and technology skills and credentials.

Assess Arizonan's attitudes toward science and technology, particularly the perceived benefit or drawbacks for themselves, for Arizona students, and for the economy. Little current data exist on how Arizona residents feel about advances in science and technology, or whether they will encourage their children to prepare for careers in scientific fields. Such information could help improve K-12 and postsecondary education and provide crucial information on how to increase the state's future talent pool for a knowledge economy.

Determine why some research initiatives pay off better for the knowledge economy than others. A few highly successful research programs positively influence CAT Measures aggregate results. Why do some programs substantially outperform others? The answer requires in-depth analyses of exemplary research projects and teams to uncover the reasons behind their steep trajectories. Conducting such analyses would be labor-intensive and involve a combination of methods — document review, performance analysis, and interviews or surveys of researchers, administrators, industrial partners, licensees, and institutional partners. From that research, an accounting of "best practices" could be assembled for use in planning and guiding future research investments.

Answer the question: "Is Arizona becoming more competitive in the national and global knowledge economy?" The CAT Measures provide unique insights into how Arizona's university-based research is performing. But how does it match up against others? This answer is essential information for policymakers. One practical approach is to convene a roundtable group of internationally prominent analysts to periodically review all of Arizona's relevant data, including the CAT Measures. The group's mission would be to determine how Arizona's research trajectory compares with that of acknowledged research leaders, both nationally and globally.

ADDITIONAL INFORMATION: RELATED LINKS ON PROPOSITION 301, TRIF, AND CAT

LEGISLATION GOVERNING PROPOSITION 301 AND TRIF

- Purpose and administration:
  www.azleg.state.az.us/ars/15/01648.htm
- Distribution of monies:
  www.azleg.state.az.us/ars/42/05029.htm

MORRISON INSTITUTE REPORTS ON PROPOSITION 301

- *Seeds of Prosperity: Public Investment in Science and Technology Research; A Study of the Economic Potential of Proposition 301 at Arizona State University and a New Model for Assessing its Long-Term Value*:
  www.asu.edu/copp/morrison/seedsofprosperity.htm
- *New Returns on Investment in the Knowledge Economy: Proposition 301 at Arizona State University, FY 2003*:
  www.asu.edu/copp/morrison/NewReturns-REV.pdf
- *New Returns on Investment in the Knowledge Economy: Proposition 301 at Arizona State University, Three-Year Aggregate Report; FY 2002-FY 2004:*
  www.asu.edu/copp/morrison/newreturns2005.htm

TRIF REPORTS ON PROPOSITION 301

- FY 2002 TRIF report to the Arizona Board of Regents:
  www.abor.asu.edu/1_the_regents/TRIF/TRIF_FY2002.pdf
- FY 2003 TRIF report to the Arizona Board of Regents:
  www.abor.asu.edu/1_the_regents/TRIF/1TRIF%20FY2003.pdf
- FY 2004 TRIF report to the Arizona Board of Regents:
  www.abor.asu.edu/1_the_regents/TRIF/TRIF%202004%20PDF.pdf
- FY 2005 TRIF report to the Arizona Board of Regents:
  www.abor.asu.edu/1_the_regents/TRIF/FY%202005%20TRIF%20Report.pdf

PROPOSITION 301-SUPPORTED RESEARCH AT ASU

- Biodesign Institute at Arizona State University:
  www.biodesign.org/
- InCise and related projects:
  incise.asu.edu/
- WINTech:
  wintech.asu.edu/
- Arizona Technology Enterprises (AzTE):
  www.azte.com

RELATED INFORMATION ON PUBLIC INVESTMENT IN SCIENCE AND TECHNOLOGY

- Morrison Institute articles:
  - "Daring to Invest in Tomorrow"
    www.asu.edu/copp/morrison/rickopedjan25.htm
  - "It Pays When Investment Foresight Is 20-20"
    www.asu.edu/copp/morrison/investmentoped.htm
- Morrison Institute's science and technology reports:
  www.asu.edu/copp/morrison/public/public2s.htm

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"IF THE COMPANIES FOUNDED BY MIT GRADUATES AND FACULTY FORMED AN INDEPENDENT NATION, THE REVENUES PRODUCED BY THE COMPANIES WOULD MAKE THAT NATION THE 24TH LARGEST ECONOMY IN THE WORLD." BankBoston study, *MIT: The Impact of Innovation*

APPENDIX A: OVERVIEW OF PROPOSITION 301 RESEARCH PROJECTS AT ASU

During the first year of Proposition 301 funding in FY 2002, ASU's supported research projects were organized in six separate and independent areas. These were distinguished as follows:

- Four emerging research fields
  - biosciences
  - information technology
  - advanced materials
  - manufacturing
- Two support areas
  - access/workforce development
  - technology transfer

Subsequent years saw ASU's Proposition 301-supported research efforts consolidated and refocused on larger, more encompassing, interdisciplinary projects coordinated under central administrative units. Since FY 2003:

- Most Proposition 301-supported research activities were brought under the umbrella of the Biodesign Institute at ASU (formerly Arizona Biodesign Institute).
- Other promising research projects funded by Proposition 301, both new and continuing, were reorganized under the title of "Capacity Building Project Investments."
- Tech transfer functions were largely spun off to Arizona Technology Enterprises (AzTE), a limited liability corporation affiliated with ASU that works with ASU scientists and engineers to package and market their inventions. Tech transfer operations through AzTE are no longer directly supported by Proposition 301 revenue, but some grant program money flows through AzTE to ASU inventors.

REVENUE AND EXPENDITURES FOR BIODESIGN INSTITUTE AND CAPACITY BUILDING PROJECTS, FY 2005 ($ MILLIONS)

	BIODESIGN INSTITUTE	CAPACITY BUILDING PROJECT INVESTMENTS
Available revenue*	$16.0	$11.2
Expenditures	$13.6	$6.7

Source: Morrison Institute for Public Policy, 2006.

Data: Office of Vice President for Research and Economic Affairs.

* Available revenue includes new revenue plus carryover of unspent funds from prior year.

BIODESIGN INSTITUTE'S SCOPE CONTINUES TO EXPAND

The Biodesign Institute is ASU's largest single recipient of Proposition 301 funding and is the primary focus of the university's Proposition 301 research strategy. During FY 2005, the Biodesign Institute:

- Administered 12 interdisciplinary research centers comprised of teams representing numerous fields of work including bioscience, bioengineering, nanotechnology, and information technology. This was a net increase of four centers over the previous year and included:
  - creation of three new centers — Bioelectronics and Biosensors, Environmental Biotechnology, and Innovations in Medicine — enabled by the hiring of three eminent scientists with expertise in these fields
  - transformation of the former center for Protein and Peptide Therapeutics into the center for Glycoscience and Technology
  - relocation of ASU's former Cancer Research Institute to the Biodesign Institute as the center for Cancer Research
- Served as ASU's link with regional bioscience research institutions through affiliated faculty, joint faculty appointments, and supercomputing facilities. The Biodesign Institute's collaborators included:
  - Translational Genomics Research Institute (TGen)
  - Barrow Neurological Institute
  - Mayo Clinic
  - Carl Hayden Veterans Administration Hospital
  - Arizona Biomedical Collaborative*

* A joint ASU-University of Arizona effort to operate a medical school campus in Phoenix.

GOALS OF THE BIODESIGN INSTITUTE'S 12 RESEARCH CENTERS, FY 2005

NAME OF RESEARCH CENTER	RESEARCH GOAL
Applied NanoBioscience (ANB)	Create better tools for monitoring health and diagnosing disease — such as a lab-on-a chip that quickly recognizes infectious viruses — through the application of advances in nanoscience, molecular biology, and genomics.
Bioelectronics and Biosensors (BB)	Develop a variety of small, low-power, handheld or disposable sensing devices for clinical diagnostics, environmental monitoring, and security and surveillance — such as tiny "sniffing" devices for detecting explosives in public places — by merging the disciplines of engineering, life sciences, and nanotechnology.
BioOptical Nanotechnologies (BON)	Develop the next generation of biosensors, implants, pharmaceuticals, biomaterials, and nanoscale power sources — such as a process for efficiently creating hydrogen fuel molecules from water — through integration of biomolecular sciences, materials engineering, and solid-state electronics.
Cancer Research (CR)	Find powerful, natural anti-cancer substances existing in our environment and develop them to create new cancer treatments — such as a compound from marine animals in Phase II human trials that has proven to be effective against gastric cancer, ovarian carcinoma, lymphomas, and renal carcinoma.
Environmental Biotechnology (EB)	Develop microbiological systems that clean up environmental pollution and transform it into renewable resources — such as bacteria that can be manipulated to generate electricity while devouring organic waste — through combining the techniques of engineering, microbiology, and chemistry.
Evolutionary Functional Genomics (EFG)	Understand how complex organisms develop from the genes of a single egg and how genomes of organisms change over time — including human disease mutations — by developing new bioinformatics techniques, better computer software for analysis of genomic databases, and other analytical tools for researchers.
Glycoscience and Technology (GT)[1]	Develop novel drugs and treatments for controlling a broad spectrum of diseases — such as stroke, heart disease, and cancer — by understanding how human sugar molecules regulate life processes.
Infectious Diseases and Vaccines (IDV)	Understand the mechanisms of both infectious diseases and their antigens, and create transgenic plants that can be used as efficient systems for producing low-cost oral vaccines against commonly fatal diseases in the developing world — such as tuberculosis, salmonella, and small pox.
Innovations in Medicine (IM)	Look for novel approaches to fundamental problems in medicine — such as treating cancer and creating vaccines — to develop innovative concepts that will form the basis for the next generation of medical treatments.
Neural Interface Design (NID)[2]	Improve mobility and brain functions for people with severe physical disabilities, due to central nervous system injuries or disease, by developing new technologies and therapies — such as microdevices that stimulate muscles and nerves to facilitate walking.
Rehabilitation Neuroscience & Rehabilitation Engineering (RNRE)	Design and develop technologies to counteract the effects of spinal cord injuries, Parkinson's disease, and cerebral palsy by replacing or repairing lost functions or by use of new assistive devices and therapeutic techniques.
Single Molecule Biophysics (SMB)	Develop new health care tools — such as faster and less expensive ways to sequence the genome of individuals to detect disease — by using nanotechnology techniques to study and manipulate the individual molecules that comprise living cells.

Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report*, September 2002, 2003, 2004, 2005; Biodesign Institute at ASU.

[1] Formerly Protein and Peptide Therapeutics (PPT).

[2] Formerly Neural Interface Engineering.

INCREASING CAPACITY FOR RESEARCH IN IT, NANO, AND WIRELESS TECHNOLOGIES

Capacity building research during FY 2005 continued to concentrate on a variety of projects, each integrating researchers from multiple disciplines with the goal of accelerating the creation of novel and sophisticated products. Research was organized under three basic umbrellas:

- information science
- materials science (nanotechnology)
- wireless technologies

The goals of the three umbrella groups are described below. The research focus for each Proposition 301-supported research center or area under these three umbrella groups is displayed in the table on the following page.

CAPACITY BUILDING PROJECT INVESTMENTS IN FY 2005:

- The Institute for Computer Information Science and Engineering (InCISE) provides leadership for research related to information technology. Its goal is to foster novel collaborative research projects by finding opportunities for interdisciplinary research that integrates new developments in computer science with other fields, such as business or the performing arts. InCISE coordinated eight research groups in FY 2005:
  - Center for Cognitive Ubiquitous Computing (CUbiC)
  - Enabling Technologies for Intelligent Information Integration (ET-I3)
  - Information Assurance (IA)
  - Partnership for Research in Spatial Modeling (PRISM)
  - Software Factory (SF)*
  - Center for Research in Arts, Media, and Engineering (AME)
  - Center for Advanced Business through Information Technology (CABIT)
  - Consortium for Embedded and Internetworking Technologies (CEINT)
- Advanced materials integrates engineering with research in several scientific fields including physical, molecular, biological, and materials sciences. The goal is to produce revolutionary nanoengineered devices such as molecular electronics-based sensors and memory devices for medical, security, and IT applications.
- Wireless technology concentrates on research and development regarding wireless devices, integrated circuits, and their combined applications as complete systems. The goal is to develop a fully integrated end-to-end system for the next generation of wireless and remote control sensing applications in biosciences, telecommunications, and remote sensing industries. This research blends the resources of two research programs at ASU:
  - WINTech (Wireless Integrated Nano Technology)
  - ConnectionOne (C1)

* Program was not funded for FY 2006.

RESEARCH FOCUS FOR CAPACITY BUILDING PROJECT INVESTMENTS, FY 2005

INITIATIVE	CENTER OR RESEARCH AREA	FOCUS
Information Science (coordinated by InCISE)	Center for Cognitive Ubiquitous Computing (CUbiC)	Design computers that will serve the needs of physically challenged individuals, such as the blind and deaf, by making the computers more aware of their surroundings and able to communicate intuitively with humans.
	Enabling Technologies for Intelligent Information Integration (ET-I3)	Solve data analysis problems such as those faced in image classification and bioinformatics by developing sophisticated and flexible new techniques for data retrieval, mining, and integration.
	Information Assurance (IA)	Develop trustworthy networked information systems and ensure the quality of information being stored, processed, and transmitted by information systems and networks.
	Partnership for Research in Spatial Modeling (PRISM)	Create new methods of visualizing 3D and higher dimensional data for better analysis, understanding, and decision-making in biology, geology, anthropology, fine arts, engineering, and other areas.
	ASU Software Factory (SF)*	Provide a hands-on learning experience in software engineering for student interns, and offer software development services to projects across campus.
	Center for Research in Arts, Media, and Engineering (AME)	Integrate high tech engineering technologies with fine arts techniques to enable new methods of artistic creativity.
	Center for Advancing Business through Information Technology (CABIT)	Partner with industry to advance knowledge about how to use technology more effectively in business management to increase performance and competitiveness.
	Consortium for Embedded Systems (CES) (formerly Consortium for Embedded and Internetworking Technologies)	Collaborate with high tech industry to expand research and skills in embedded systems through an integrated program of targeted research, visiting professorships, continuous curriculum development, for-credit internships, and support for talented students through scholarships and assistantships.
Advanced Materials	Integrated Micro/Nanosystems	Create new micro and nanoscale applications and devices for sensing, memory storage, optics, and communications technologies.
Wireless Technology	WINTech (Wireless Integrated Nano Technology)	Work with ConnectionOne to research and develop autonomous, wireless, nano device systems with remote control and sensing applications for the biosciences, telecommunications, and remote sensing industries, as well as for defense and environmental purposes.
	ConnectionOne (C1)	A National Science Foundation/University Cooperative Research Center at ASU with 18 member companies and 4 academic partners working on industry R&D needs in wireless technology.

Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

* Program was not funded for FY 2006.

A MARKET-ORIENTED APPROACH TO TECHNOLOGY TRANSFER

Arizona Technology Enterprises (AzTE) is a limited liability 501(c)(3) corporation closely affiliated with ASU. In FY 2003, AzTE replaced ASU's former technology transfer unit. As a limited liability corporation, AzTE can practice a "technology venturing" approach to commercialization of university inventions that is more business friendly than the passive and protective handling of university intellectual property practiced by traditional university tech transfer offices.

Tech venturing allows AzTE to be:

- more flexible in structuring licensing and partnership deals with companies
- more responsive to the time-sensitive development demands of the technology industry
- faster at licensing and commercializing new inventions

ARIZONA TECHNOLOGY ENTERPRISES IN FY 2005:

- actively assessed and marketed ASU inventions through entrepreneurial partnerships, relationships with investors, and business development services for new startup companies
- continued the Technology Venturing Clinic, offering selected graduate students an opportunity to work with AzTE on tech venturing projects including patent investigation, business modeling, deal structuring, and market assessment and research
- received no Proposition 301 monies for operations*, but remained a resource for Proposition 301-supported research at ASU

* Proof of concept grants for faculty inventors continued to be funded by Proposition 301.

NEW VERSUS OLD APPROACH TO COMMERCIALIZING UNIVERSITY INVENTIONS

PROPOSITION 301 TECH VENTURING	TRADITIONAL UNIVERSITY TECH TRANSFER
Actively assesses new technologies for commercial value and marketability	Provides passive protection of new technologies
Bundles related inventions together as a portfolio to simplify and speed licensing	Licenses new inventions individually
Offers business development services and risk-sharing through partnerships with entrepreneurs	Does not assist companies after inventions are licensed
Provides entrepreneurial assistance for promising faculty startups	Follows a "hands off" policy regarding faculty involved with startups
Run by individuals with business experience including venture capital and product and business development	Staffed with university personnel

Source: Morrison Institute for Public Policy, 2006.

Data: Arizona Technology Enterprises and ASU Office of the Vice President for Research and Economic Affairs.

"IF YOU KNEW IN ADVANCE WHAT THE PAYOFF WOULD BE, THEN IT'S NOT R&D." WALTER ROBB, former head of research at General Electric

APPENDIX B: ASU'S ANNUAL PERFORMANCE MEASURES AND DELIVERABLES REPORTED TO ARIZONA BOARD OF REGENTS

The Arizona Board of Regents requires each university to propose appropriate research projects and develop specific performance measures and deliverables before approving allocations of Proposition 301 funds to the universities. Data on the performance measures and deliverables have been monitored by the universities and reported each year to the Regents, the Governor, and the Arizona Legislature. In addition, Morrison Institute has reported and analyzed ASU's results separately and categories relevant to the knowledge economy in a series of reports including *Seeds of Prosperity* and both *New Returns* reports (see page 10 for more information, and page 20 for links to the reports). During the four years of Proposition 301 funding, both the funded projects and the performance measures and deliverables have changed and evolved in response to opportunities, new hires, and strategic decisions. This process is expected to continue in the future.

Highlights of FY 2005 results include:

- $35.9 million increase in total external funding for research, and $2.5 million in revenue from new products and new company startups facilitated by Arizona Technology Enterprises (AzTE)
- 13 new courses developed in science and technology, and 177 undergraduates who gained research experience
- 41 new U.S. patents, 10 new products developed, and 10 companies citing ASU as a factor influencing their relocation or expansion
- 32 ASU post-doctoral fellows, and 63 graduate students trained in science and technology added to the workforce
- 53 more computer science graduates than in previous year
- 71 students gained experience in industry as interns
- 32 new tenure-track and research faculty successfully recruited, and 10 visiting scientists appointed
- 3 new research centers at Biodesign Institute started by newly hired eminent scientists

Comparing FY 2005 results to FY 2002, most performance measures for Proposition 301-related research activities showed substantial increases:

- Annual growth in external funding nearly tripled from $12.0 million to $35.9 million.
- The value of new products increased by more than 6 times from $0.4 million to $2.5 million.
- Newly introduced courses in biosciences, information technology, and nanotechnology more than tripled from 4 to 13.
- New patents almost quadrupled from 11 to 41.
- New graduate students enrolled more than quadrupled from 29 to 121.
- Undergraduates with research experience more than quadrupled from 39 to 177.

These are just some of the results for ASU's Proposition 301 performance measures reported to the Board of Regents. The tables and charts that follow present all of ASU's latest results from the Board of Regents' approved performance measures and deliverables plus some additional data on new hires and visiting scientists. As Morrison Institute has done in the past, all of the data are cast in five categories relevant to the knowledge economy: new money, new programs, new ventures, new skills, and new talent. The first table on page 31 provides comprehensive results for FY 2005 only. The following tables and charts on pages 32-34 illustrate performance trends across all four years of Proposition 301 funding, FY 2002 through FY 2005. (Note: Data do not cover Proposition 301 funds allocated to ASU East or West for capital infrastructure development and building and central plant expansion.)

ASU PROPOSITION 301 PERFORMANCE MEASURES FOR ARIZONA BOARD OF REGENTS, FY 2005

NEW MONEY	NEW PROGRAMS	NEW VENTURES	NEW SKILLS	NEW TALENT
$31.2 million increase in new federal awards $4.7 million increase in industrial contracts and donations $2.5 million earned for ASU in royalties and other fees from new products and new company startups	13 new courses in Bio, IT, and Nano 3 new research centers created at Biodesign Institute Cancer Research Institute integrated into Biodesign Institute State of the art wireless design and testing facility completed Distinguished lecture series launched to bring attention to embedded systems research Certification program created to recruit new secondary teachers from students with strong mathematics backgrounds	14 new research collaborations with industry and national labs 2 new software packages developed for clients 10 new products in marketplace 28 licenses/options signed 41 US patents approved 168 patent applications filed 166 inventions disclosed 8 business plans written for new and potential startup companies 10 companies citing ASU as factor in relocating or expanding in Arizona 20 tech transfer portal inquiries	64 new post-doctoral students in pipeline 121 new graduate students in pipeline 32 post-doctoral students entering workforce 63 graduate students earning degrees and entering workforce 177 undergraduate students with research experience 53 more computer science graduates than in previous year 71 student interns in industry	32 new tenure-track and research faculty 10 visiting scientists

Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report*, September 2002, 2003, 2004, and 2005.

ASU PERFORMANCE MEASURES BY FISCAL YEAR

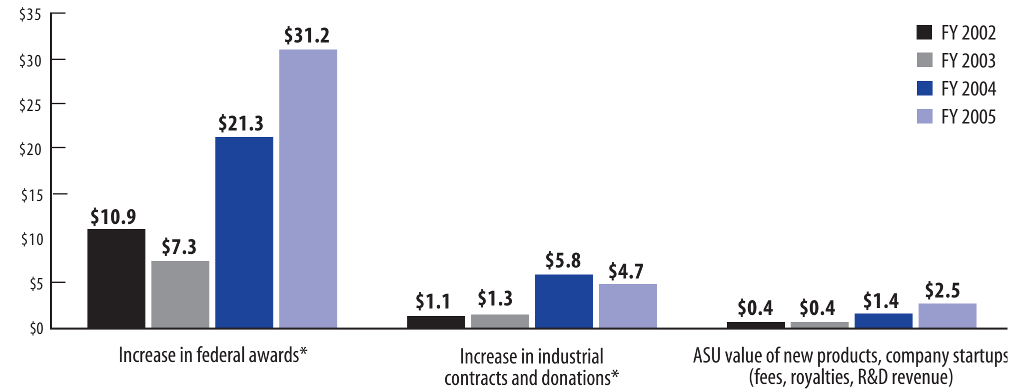
NEW MONEY: BIG GAINS OVERALL, BUT NOT IN 2003 ($ MILLIONS)

PERFORMANCE MEASURES	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005
Increase in federal awards*	$10.9	$7.3	$21.3	$31.2
Increase in industrial contracts and donations*	$1.1	$1.3	$5.8	$4.7
ASU value of new products, company startups (fees, royalties, R&D revenue)	$0.4	$0.4	$1.4	$2.5

Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

* Increase is for each year over the previous year.



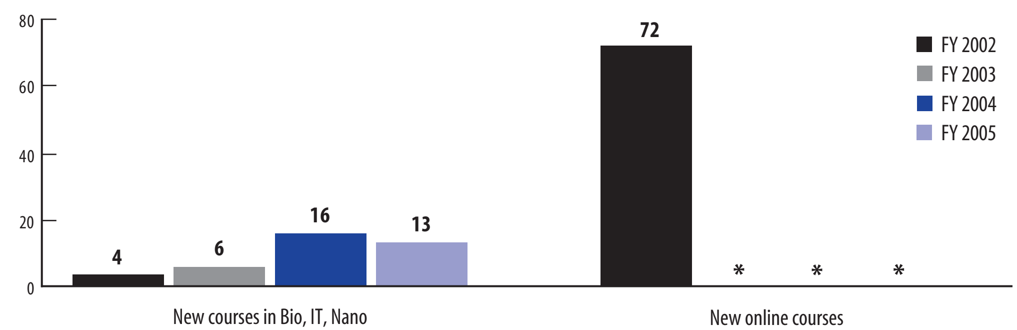
NEW PROGRAMS: MIXED RESULTS FOR ONGOING PROGRAMS

PERFORMANCE MEASURE	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005
New courses in Bio, IT, Nano	4	6	16	13
New online courses	72	*	*	*

Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

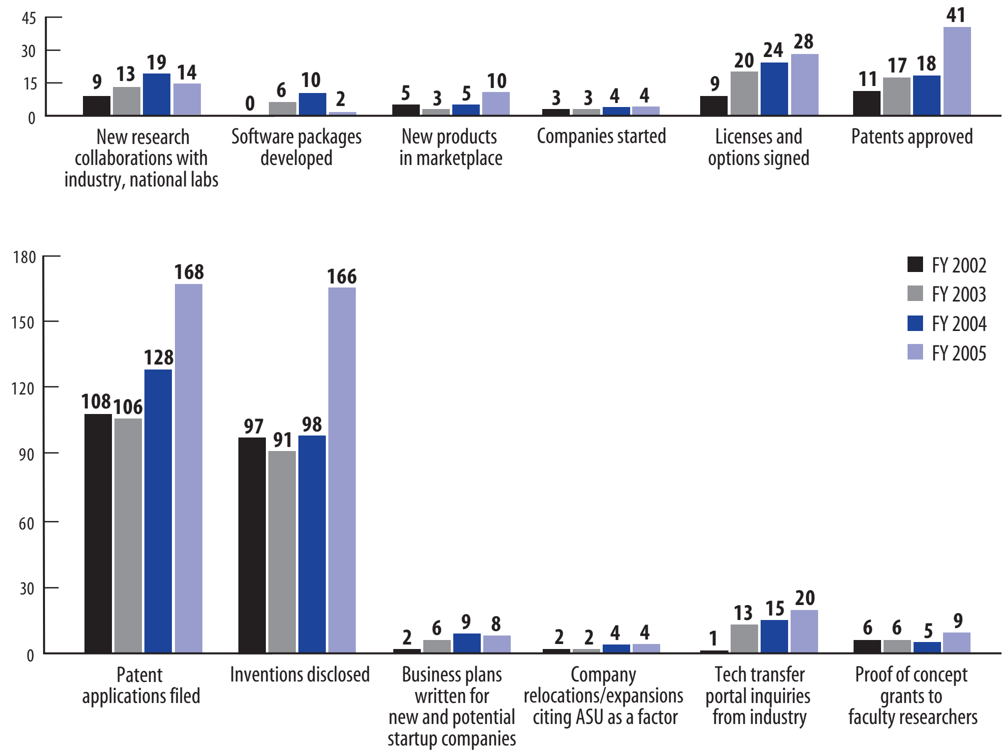
* Program was not funded after FY 2002.



ASU PERFORMANCE MEASURES BY FISCAL YEAR (CONT.)

NEW VENTURES: LEADING GAINERS ARE INVENTIONS AND PATENTS

PERFORMANCE MEASURE	**YEAR 1 FY 2002**	**YEAR 2 FY 2003**	**YEAR 3 FY 2004**	**YEAR 4 FY 2005**
New research collaborations with industry and national labs	9	13	19	14
Software packages developed	0	6	10	2
New products in marketplace	5	3	5	10
Companies started	3	3	4	4
Licenses and options signed	9	20	24	28
Patents approved	11	17	18	41
Patent applications filed	108	106	128	168
Inventions disclosed	97	91	98	166
Business plans written for new and potential startup companies	2	6	9	8
Company relocations/expansions citing ASU as a factor	2	2	4	10
Tech transfer portal inquiries from industry	1	13	15	20
Proof of concept grants to faculty researchers	6	6	5	9



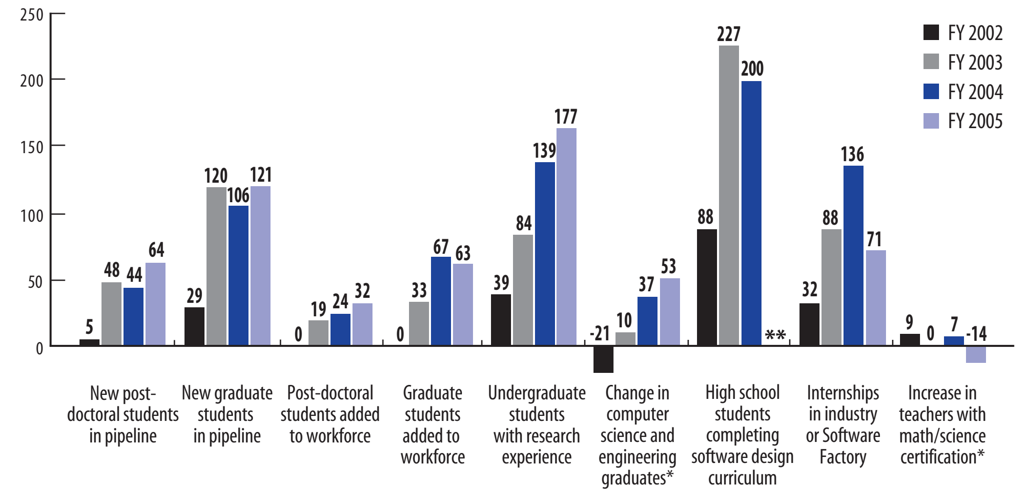
Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

ASU PERFORMANCE MEASURES BY FISCAL YEAR (CONT.)

NEW SKILLS: MOST MEASURES SHOW OVERALL GAINS

PERFORMANCE MEASURES	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005
New post-doctoral students in pipeline	5	48	44	64
New graduate students in pipeline	29	120	106	121
Post-doctoral students added to workforce	0	19	24	32
Graduate students added to workforce	0	33	67	63
Undergraduate students with research experience	39	84	139	177
Change in computer science and engineering graduates*	-21	10	37	53
High school students completing software design curriculum	88	227	200	**
Internships in industry or Software Factory	32	88	136	71
Increase in teachers with math/science certification*	9	0	7	-14



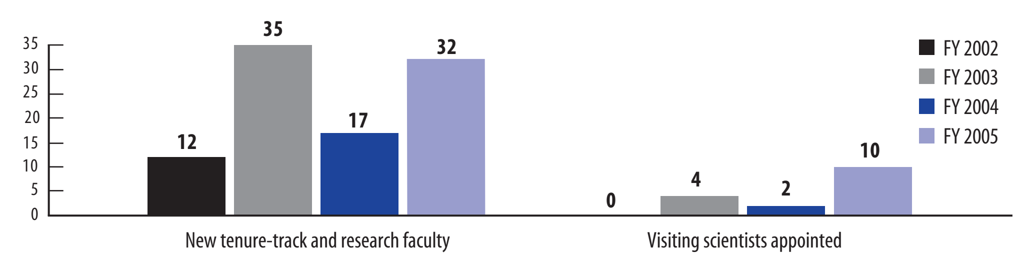
Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

* Change or increase is for each year over the previous year. ** Program was not funded for FY 2005.

NEW TALENT: MORE RESEARCHERS HIRED

PERFORMANCE MEASURES	YEAR 1 FY 2002	YEAR 2 FY 2003	YEAR 3 FY 2004	YEAR 4 FY 2005
New tenure-track and research faculty*	12	35	17	32
Visiting scientists appointed*	0	4	2	10



Source: Morrison Institute for Public Policy, 2006.

Data: *Technology and Research Initiative Fund (TRIF) Annual Report,* September 2002, 2003, 2004, and 2005.

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