Innovation America

Investing in Innovation

NATIONAL GOVERNORS ASSOCIATION

PEW CENTER on THE STATES

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Foreword

The National Governors Association's *Innovation America* initiative focused on strengthening our nation's competitive position in the global economy by improving our capacity to innovate. The goal was to give governors the tools they need to improve math and science education, better align post secondary education systems with state economies, and develop regional innovation strategies.

To guide the *Innovation America* initiative, we assembled a bipartisan task force of governors, corporate CEOs and university presidents. Working with the NGA Center for Best Practices, this task force provided valuable advice on innovation strategies in general and assisted in the development of the initiative's reports and forums. Through a variety of events and publications, we collected and shared best practice information to ensure that every state—and the nation—is equipped to excel in the global economy.

All of the documents produced during this initiative can be found online at www.nga.org/center/innovation.

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Preface

"Ask any CEO in the world to write a top-five wish list," reports the Harvard Business Review, "and 'more ideas-better ideas!' will show up in some form." This is true, in large part, because "ideas and innovation are the most precious currency in the new economy."

Innovation is too important to leave to chance. So business leaders are searching the world—not just for ideas, but for new business models and partners that will help foster innovation in a systematic fashion.

The nation's governors can help. And in fact, they are.

While CEOs are looking for "more ideas-better ideas," governors are looking for "more jobs-better jobs." And, like their business counterparts, they know that innovation is the key to success.

That's why states are creating their own research and development (R&D) funds to seed cutting-edge research, build new research institutions, and gain new talent. The leading states are using these funds to partner with business—so that corporations will stay securely rooted in their own backyards instead of looking abroad for future expansion.

Investing in Innovation speaks to these connections—and the opportunity governors have, working with business leaders and others, to build R&D strengths and create a collaborative culture that will drive innovation to new heights. This benefits not just individual states, but the nation as a whole.

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Executive Summary

The pressure on the 50 states to attract jobs, money and a talented workforce has been building for decades. It's now singularly intense. Huge new overseas competitors like China and India are competing for the same pools of cash and people as California, Indiana and the rest. Moreover, some international players like Singapore, Finland and Ireland are demonstrating remarkable prowess at strategically planning for economic growth. Meanwhile, the speed with which innovation spreads makes no competitive lead secure.

As a result, today states must accelerate their efforts or risk becoming economic backwaters. Specifically, they must become places where new ideas are discovered, invented or given their first big break.

The good news is that new ideas are virtually limitless. Ideas don't need to be attracted from other places; each state can discover its own. For a growing number of states, this quest has taken the form of investing state dollars in research and development (R&D). R&D is the key to an innovation treasure chest that contains new ideas, new products, new technologies and new ways of doing business. In advanced economies, it is the tried and true route to prosperity.

When it comes to funding R&D, states are the newest players in the game, and the smallest. But while the actual money available from states is dwarfed by that offered by industry and the federal government, states have the capacity to influence the future in a dramatic fashion. Industry tends to fund narrowly, and federal investments have plummeted as a share of total R&D. Of particular significance to governors, their staffs and other stakeholders: states' direct involvement in R&D can spur innovations that serve specific economic and social needs within their own borders.

How is this accomplished? Many of the answers have been uncovered through 50-state research conducted over the last six months by the Pew Center on the States, an initiative of The Pew Charitable Trusts, and the National Governors Association. This report is the product of that work.

Investing in Innovation provides a snapshot of trends in the states and identifies a wide range of strategies now employed. California's big investments, such as $3 billion for stem cell research, have already grabbed national headlines. But states like Arizona, Indiana and North Dakota, which haven't historically been big R&D spenders, are also investing public dollars. This analysis provides a first look into which states are taking action and why, what they are funding, and how.

Moreover, this report provides clear guidance on how to design R&D investments that work.

The biggest lesson learned is straightforward: How much a state spends on R&D is secondary. How it is spent is absolutely critical. Key to this truth is the notion that R&D efforts must be considered investments, not expenditures.

Just like any investors, states must begin by carving out areas where returns are tangible and commensurate with risks taken. Not only do the benefits include building talent and high-paying jobs in the state, but they also can be seen in

solutions to pressing social problems, improved business efficiency and productivity, and success in global markets.

Successful states get to these results with steps that are uniquely in the hands of governors, legislators and other policy makers. These include:

- Develop a statewide research and innovation strategy that not only puts in place all the components for innovation, but aligns them in ways that provide advantages to in-state companies;
- Make investments to gain talent, build top-notch research enterprises and compete for federal dollars in those focused areas where the state can be world-class;
- Encourage, even mandate, collaboration among universities, the private sector and other institutions;
- Put world-class professionals, not political pals, in key positions;
- Create an organization and consistent funding source that facilitates a continuity in R&D partnering and spending; and
- Hold the recipients of public investments accountable for delivering on promised benefits.

In practical terms, this means that there are no magical shortcuts when it comes to investing in innovation. But the **six guidelines** and accompanying case studies in the following pages will help governors and a range of stakeholders (CEOs, legislators, advisors, fund managers) put the right structures, processes and people in place.

Six Guidelines for R&D Investments

GUIDELINE ONE:

Put all the pieces together. Embed your R&D investments in a 21st century innovation strategy 14

GUIDELINE TWO:

Make the right bets. Your state has strengths—and needs—so find and fund them 20

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Invest in collaboration. Innovation is a team sport, with players from universities, industry and government 30

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Enlist experts. There are lots of hard decisions in this process. You'll need the best advice to make them well 38

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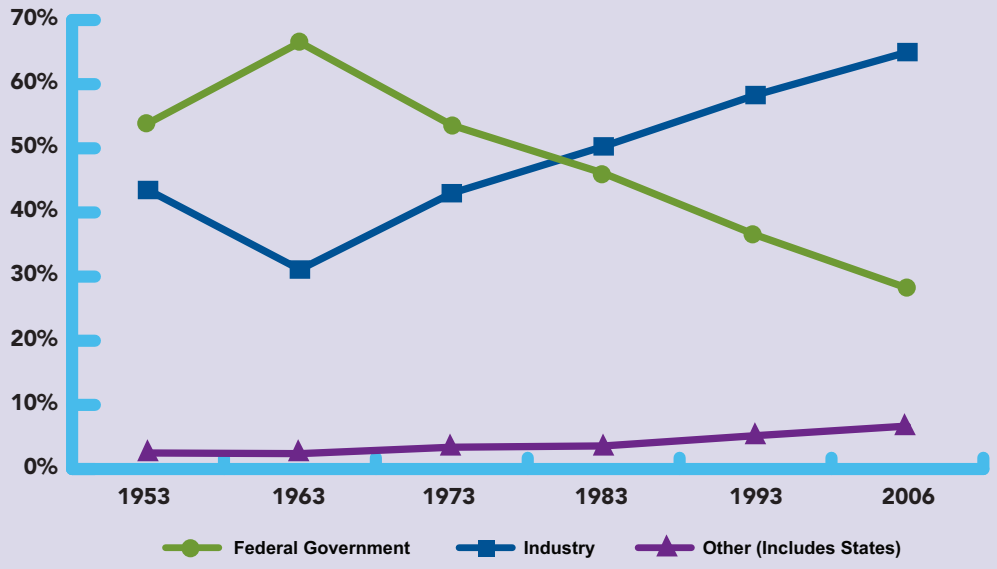
Measure results. It isn't easy—but it is critical to success 56

Introduction

From Maine to Hawaii, governors and their staffs confront a world in which the only certainty is change. Yesterday's technological breakthrough is today's commonplace tool and tomorrow's electronic relic. U.S. corporations and universities no longer corner the market on new ideas. Fifty-two of the 57 major telecom research initiatives of the last five years, for example, were located outside the United States.[1] And this country's share of R&D spending, patents, scientific publications and science and engineering degrees is in decline.

The United States still holds an edge in flexible thinking and free markets. But countervailing influences have permitted others to match—and in some areas exceed—this country as the world's innovation leaders. Weaknesses in K-12 education, a lack of math and scientific expertise and shortages of highly skilled workers have all contributed to this state of decline. "The U.S. needs to decide to compete," says Intel Chairman Craig Barrett. "Right now we are riding on past investments and not investing for the future."[2]

Federal R&D Funding Share Declines as Industry's Rises



Source: National Science Foundation Division of Science Resources Statistics, "National Patterns of R&D Resources," http://www.nsf.gov/statistics/infbrief/nsf07317/ (accessed June 25, 2007).

Industry and Federal Government R&D

Most industry investment is focused on development, while the federal government remains the top funder of basic research.

	Industry	*Federal Government*
Basic Research Support	$10 billion	$36 billion
Applied Research Support	$36 billion	$25 billion
Development	$153 billion	$32 billion

National Science Foundation Division of Science Resource Statistics, "Science and Engineering Indicators 2006," http://www.nsf.gov/statistics/seind06/ (accessed June 25, 2007).

The federal government used to provide the lion's share of dollars for R&D, but it has lagged in recent years.[3] Much of the slack has been taken up by the private sector. But industry's investments are often sharply targeted and may not coincide with the broader needs of states.

A growing number of leaders in the states see this situation as both a responsibility and an opportunity for their citizens. They are developing their own research and development capacity by investing in so-called R&D funds, which advance states' interests in the innovation marketplace.

The Battelle Memorial Institute produces the authoritative annual look at R&D trends in the United States and noted in its 2006 forecast the "aggressive role" state governments have assumed, citing California, Iowa, Ohio, New York and Texas.[4] Clear evidence of this trend is also emerging in states like Arizona, North Dakota and Oklahoma that haven't historically been big R&D money-spenders. (See map titled "Coast to Coast R&D Investments.")

Beyond educated self-interest and global pressures, the states have been catalyzed by a number of other factors including:

- The rise of knowledge economies, where a majority of workers are employed in jobs where they use their heads more than their hands;
- The public desire for cures to illnesses that plague millions, such as Alzheimer's, diabetes and cancer;
- The rapid emergence of new markets in areas such as alternative energy; and
- The realization that every industry—not just high tech and bio tech—needs to innovate in order to compete in the global marketplace.

R&D—and the benefits from the innovations it creates—was always a part of a good economic development strategy. But in recent years, its importance as an economic development tool has grown and become better understood. A 2005 study from the Federal Reserve Bank of Cleveland looked at drivers of state per capita income. The greatest explanatory factors were those relating to a state's "innovation" (as measured by the number of patents issued and other indicators) and "workforce skills" (as measured by educational attainment and other indicators).[5] Stanford economist Paul Romer, meanwhile, makes the case for a "new growth theory," arguing that "in advanced economies, smart people and new ideas are the primary catalysts for economic growth."[6]

As R&D investments mature, they offer returns in the form of top talent (including engineers and scientists), high-paying jobs, new infrastructure,

Coast to Coast R&D Investments

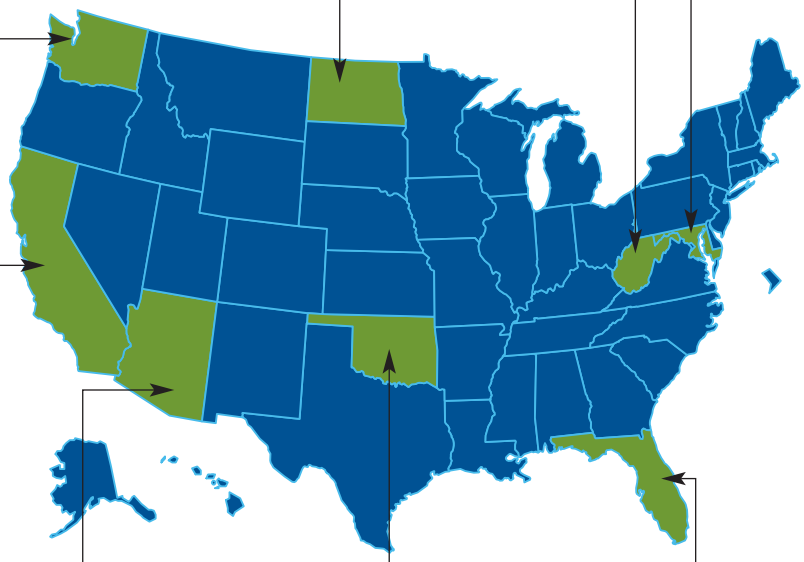
States' R&D war chests dot the national landscape from coast to coast. Both large and small states are creating their own funds to seed cutting-edge research, build research institutes and gain new talent. Mapped here is just a sample of states' new bets on innovation.[7]

WASHINGTON
Life Sciences Discovery Fund ($350 million over 10 years)
Washington's fund is dedicated to bioscience research that provides economic and health benefits to the state's residents.

NORTH DAKOTA
Centers of Excellence ($50 million)
North Dakota funds public-private centers of excellence that focus on state strengths such as surface protection, leveraging at least a 2:1 match from the private sector (total, $150 million).

WEST VIRGINIA
Research Challenge Fund ($4 million annually)
Using a unique funding mechanism harnessing lottery revenue, West Virginia makes targeted investments to increase competitiveness for federal and other outside R&D funding.

MARYLAND
Stem Cell Research Fund ($23 million annually)
Recognizing an emerging need in stem cell research, Maryland's fund focuses its investments on quickly translating new treatments into benefits for patients.



CALIFORNIA
Institutes of Science and Innovation ($400 million)
California's initiative unites universities and industry partners to address state problems such as climate change, energy and traffic congestion. An additional $800 million was raised from private-sector partners (total, $1.2 billion).

ARIZONA
Science Foundation Arizona ($135 million)
To strategically strengthen the state's scientific, engineering and medical research programs, Arizona established a public-private non-profit partnership that receives half of its money from the state and half from the private sector (total, $270 million).

OKLAHOMA
Oklahoma Center for the Advancement of Science and Technology ($29 million annually)
Oklahoma is investing millions in nanotechnology research and other fields in order to become the "research capital of the plains."

FLORIDA
Scripps Florida ($310 million)
As one of many steps taken to establish bioscience excellence, Florida recently built a new facility to house the world-class Scripps Institute.

enhancement to their reputations and the potential to leverage additional federal, private, philanthropic and other research dollars. In addition, they help attract students who provide the workforce needed by industry and who may become tomorrow's science stars and in-state entrepreneurs.

Innovation-based R&D funds have been steadily gaining favor for decades—but their form has changed dramatically in recent years. An increasing number of states have moved from a linear approach that simply funds university research in hopes that such investments will eventually reap worthwhile returns, to new approaches that encourage public-private collaboration and focus on making competitive investments with greater accountability for results. (See table titled "How State R&D Investments are Evolving.")

One of the most exciting new developments is dubbed "open innovation." Open innovation replaces secretive research performed behind locked doors with a collaborative approach that utilizes the best minds everywhere in a constant pursuit of more and more valuable ideas, products and processes.

"The locus of innovation," says Henry Chesbrough, executive director of the Center for Open Innovation at the University of California Berkeley, "has migrated beyond the confines of the central R&D laboratories of the largest companies and is now situated among various start-ups, universities, research consortia and other outside organizations."[8]

A growing number of states are moving in this direction. The Georgia Research Alliance is a public-public partnership that directs supplemental funding (over $400 million so far) to Georgia universities and aims to stimulate the commercialization of research. Its signature Eminent Scholars program recruits enterprising scientists to help seed companies to fuel the economy. Ohio's $1.6 billion Third Frontier initiative is a comprehensive, professionally-run effort to build world-class research capacity, promote interaction between research and industry, and commercialize R&D.

Spending lots of state money on research doesn't translate automatically into economic benefits—but smart spending optimizes the chance of success. The funding available from states is still relatively small, compared with both the federal government and industry. But it can have a potent multiplier effect when governors use limited investments to bring together other players—notably universities, research institutions and the private sector—that are already putting in a great deal of money.

In a recent study about the private sector that has clear applicability to public-sector initiatives, consultants at Booz Allen Hamilton reported:

> *"The quest for innovation has long been a faith-based initiative: Spend more and profit will come [but] there is no relationship between R&D spending and the primary measures of economic or corporate success, such as growth, enterprise profitability and shareholder returns… Superior results, in most cases seem to be a function of the quality of an organization's innovation process—the bets it makes and how it pursues them—rather than the magnitude of its innovation spending."*[9]

Of course, it's too early to say that any state has an absolute edge on smart investing. But it is clear what smart spending is not. A scattershot

approach, for example, simply diffuses opportunity. Investments that don't link to a state's needs and its industry strengths will lack momentum and support needed for solid returns. An effort that lurches from one approach to another will go no place—slowly.

This Report

In an effort to establish some clear, replicable guidelines for investing in innovation, the Pew Center on the States in collaboration with the National Governors Association has created a set of guidelines for governors to help them leverage their investments, bridge the essential relationships between universities and the private sector, build an environment hospitable to innovation and more.

The guidelines that follow are based on solid research, but more importantly, they are grounded in the real-world experiences of the states. Practices that have worked well in one state are certainly worth considering in others.[10]

How State R&D Investments Are Evolving

Every evolutionary process involves fits, starts and dead-ends. This is certainly true of the development of R&D investments. The following may not reflect every state's experience, but it describes the general evolution of state-supported R&D.

In the 1980s…

- State investments are small, often under $5 million;
- Funds flow directly to individual universities;
- Universities invest in faculty research, new hires and centers of excellence; and
- Decisions are made in a deeply decentralized way, with little regard for statewide strategic planning.

Twenty years later…

- The size of state investments is on the upswing, with a number over $100 million;
- Direct funding to universities fades;
- States focus on science and technology centers fueled by industry-university or university-university partnerships; and
- Funding decisions go through a criteria-based competitive process aimed at finding fields most critical to the economic growth of the state.

And now…

- Dollar amounts continue to grow;
- Intermediary organizations or public-private partnerships, often operating outside state government and the university systems, are used to make the R&D investment decisions;
- States are investing in specific technology and research fields, including bioscience, stem cell and alternative energy; and
- Funding decisions are based on desire for a "state dividend," including quality of life improvements, better health outcomes and economic transformation.

GUIDELINE ONE

Put all the pieces together.

Embed your R&D investments in a 21st century innovation strategy.

Investing in research and development won't lead to meaningful returns if it's done in isolation. R&D yields the greatest benefit when it's planted in a state with a full-fledged innovation economy that includes a variety of interrelated elements. The exclusion of even one can be detrimental—or even fatal—to the process. The list includes: universities and public or private research laboratories to create new ideas; buy-in and leadership from industry; effective ways for individuals and entities to communicate with one another; superior infrastructure, including laboratories, transportation and high-level communications assets; talented workers and a good quality of life to attract them; investment money and an entrepreneurial culture that will help to bring new ideas to market.

This is entirely in keeping with the enormous and sustained success of Silicon Valley. Prominent business leaders and academics recognize the Valley has been successful partly because of networks and interactions among a vibrant mass of people, firms and institutions.[11]

Economic strategy was somewhat easier in past generations. The destiny of states was largely shaped by their natural assets: a pleasant climate, abundant natural resources, availability of land, coastal locations, and so on. Though these continue to be important factors for the states, it has become abundantly clear that 21st century places will succeed because of assets they create, not assets they inherit.

Highly educated people, great universities and networks for interaction can't be found in the earth, nor do they appear through spontaneous generation. They come into being as the result of well thought out and strategic public policy.

Simply put, the components for innovation can be had by nearly any state with the necessary will and focus. As Jim Collins, author of *Good to Great*, says, moving an innovation environment from a good one to a great one "comes about by a cumulative process…step by step, action by action, decision by decision, turn by turn of the flywheel—that adds up to sustained and spectacular results."[12]

But as states—and countries—try to accomplish similar goals, the next decades are likely to be highly competitive. Two factors will make the difference: a sustained resolute effort that can outlast setbacks and disappointments and a dogged determination to know how innovation happens, where it happens and how it's measured. The stakes are too high to leave to chance.

A FRAMEWORK FOR

Understanding Innovation

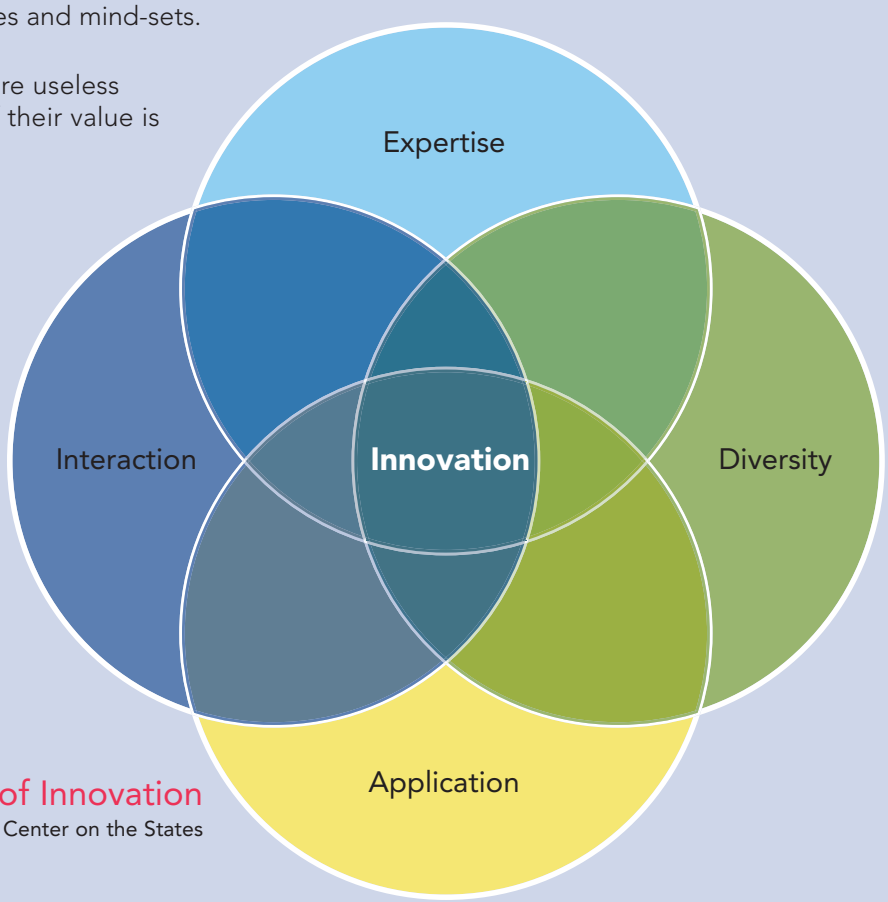
People studying innovation note four components of an innovative place—whether a company, research facility or state:

- **EXPERTISE.** New discoveries, new knowledge and new insights come from smart people who are given the resources necessary for success.

- **INTERACTION.** Face-to-face is still very important for the exchange of ideas and synergy that create new business models, marketing plans or products.

- **DIVERSITY.** Ideas will only get better when they are openly discussed and considered by a mix of people with a variety of research fields, backgrounds, approaches and mind-sets.

- **APPLICATION.** Ideas are useless unless used. The true proof of their value is in commercialization.



The Four Components of Innovation

Source: Pew Center on the States

Can states influence these components?

The answer is an emphatic yes—through their investment decisions and policy choices.

What States Are Doing

Even a short list of recent state actions seems enough to show that states are sharpening their innovation components through R&D investments.

1. States are building EXPERTISE by putting financial muscle behind research, building strong research capabilities and attracting world-class talent.

Connecticut – In 2005, the state joined the ranks of California, New Jersey and other states investing in stem cell research. With an initial investment of around $20 million and commitments of at least $10 million per year for the next 10 years, the Connecticut Stem Cell Research Fund, housed within the Department of Public Health, recently released 21 awards worth $19.75 million.

Michigan – With an appropriation of nearly $400 million in 2006 and a commitment to spend an estimated $2 billion over ten years, Michigan's 21st Century Jobs Fund is a direct effort to diversify the state's economy. The fund seeks to seed applied research in four areas: life sciences; alternative energy; advanced automotive, manufacturing and materials; homeland security and defense. Situated within the Economic Development Corporation, it builds off the state's efforts to create a life sciences corridor earlier in the decade.

Florida – With a $310 million appropriation by the state legislature, Florida enticed the Scripps Institute—a global leader in basic biomedical research—to create a new facility in Palm Beach County and become the capstone of a bioscience research industry. The new facility will be complete by early 2009.

Georgia – The Georgia Research Alliance (GRA), a public-private partnership established in 1990, uses part of its annual budget of nearly $30 million in public and private funding to recruit eminent scholars to Georgia universities. The program typically provides scholars with a $1.5 million endowment, half paid by the private sector the host university raises and half paid by the GRA. To date, 54 scholars have been recruited to lead research in three strategic areas: advanced communications, bioscience and nanoscience, and advanced materials.

Kentucky – Established in 1997, Kentucky's "Bucks for Brains" program has invested about $350 million in state funds to recruit top talent to serve as endowed chairs and new professors at the state's flagship universities, including the University of Louisville and the University of Kentucky.

2. States are orchestrating INTERACTION by cultivating strong networks, well-designed research facilities and compact geographical areas.

California – The Bay Area Science and Innovation Consortium (BASIC) is a collaboration of the Silicon Valley region's major research universities (Stanford, UC Berkeley, etc.), businesses (IBM, Genencor, Hewlett-Packard, etc.) and national labs (Lawrence Livermore, NASA Ames, Sandia, etc.) designed to take advantage of unique R&D capabilities to provide solutions for critical national and regional challenges. BASIC has standing teams dedicated to action on advocacy, intellectual property, marketing and communication, and R&D collaboration.

Georgia – The Georgia Research Alliance (GRA) funds "Venture Lab" fellows—experienced entrepreneurs who work with faculty members to evaluate research and innovations and build companies that meet a demonstrated commercial need.

Oregon – The state-supported Oregon Nanoscience and Microtechnologies Institute (ONAMI) advances the state's nanotech economy through close public-private partnerships. One unique feature is a facility-sharing agreement through which any member of ONAMI can use facilities such as the University of Oregon's Center for Advanced Materials, which includes five separate labs.

Pennsylvania – Keystone Innovation Zones were established in 2004 to encourage communities with universities and research institutions to locate firms in close proximity to bring entrepreneurs and researchers physically together. Zones are supported by the state with annual operation grants up to $250,000 and tax credits totaling $25 million annually.

3. States are ensuring that sparks fly by putting people from DIVERSE knowledge fields and cultures together

California – Supported in part by state appropriations, the University of California's Discovery Grants program requires joint submission of proposals between a principal investigator and an industry sponsor as a condition of funding. The program also recently launched a "Pilot Project for Multidisciplinary Research" to develop highly innovative industry-university research partnerships to help California solve problems in three areas: energy and environment, health and wellness, and rapid application of nanotechnologies.

Kansas – The state's Bioscience Authority administers a Bioscience Research and Development Voucher Program that provides an incentive for bioscience companies or entrepreneurs to do business in Kansas and encourages collaboration between industry and academia.

Wisconsin – In 2004, Wisconsin pledged $50 million to build two Institutes for Discovery, one public and one private on the University of Wisconsin campus. The investments build on

$317 million in public and private funds recently used to build research facilities through the BioStar program. The Institutes will occupy an entire block of the university campus and bring together multiple disciplines (biology, chemistry, computer science, engineering, nanotechnology, etc.) to conduct stem cell and other research.

Arizona – The $69 million Biodesign Institute at Arizona State University, built with Proposition 301 money, combines in one place the university's biomedicine, biotechnology, nanotechnology, information technology, materials science and engineering research programs.

4. States are making the APPLICATION or commercialization of research more of a sure thing by requiring university-industry partnerships and peer review prior to making investments.

Indiana – Established in 1999, the 21st Century Research and Technology Fund emphasizes the creation of academic and commercial-sector partnerships in making awards and expects significant leveraged funds from partners involved in the projects. For the one-year period ending in July 2006, the fund made 21 awards totaling nearly $26 million for commercialization of a wide range of emerging technologies.

Texas – Texas' Emerging Technology Fund has created seven Regional Centers of Innovation and Commercialization across the state to coordinate proposal development, intake and evaluation, and build partnerships among universities and industry. The fund recently awarded $13 million in grants to help commercialize promising technologies, including $3 million to NanoCoolers Inc. of Austin, to complete the development of a more efficient cooling system designed for use in refrigerators and other appliances.

Connecticut – The state's Yankee Ingenuity Technology Program is designed to accelerate innovation by encouraging Connecticut businesses, particularly emerging enterprises, to collaborate with Connecticut colleges and universities. In the first round of required peer review, technical experts review scientific merit; in the second, entrepreneurs and academics review commercial and other potential including through oral presentations by principal investigators.

Illinois – Illinois recently launched the INNOVATE Illinois program to recognize and grow innovative companies and ideas. Businesses apply through a competitive process to receive one of twelve $10,000 planning grants, which are accompanied by regional conferences, mentor and entrepreneurial advice and other technical assistance. Grantees spend six months developing and implementing Individual Growth Plans designed to refine and take their innovation to a broader scale.

GUIDELINE TWO

Make the right bets.

Your state has strengths—and needs—so find and fund them.

It would appear obvious that every state isn't going to be a world-class bioscience hub or the capital of alternative fuels innovation. But this brutal fact is all too often forgotten. A 2001 survey found that 41 of the 50 states had "engaged in some kind of effort to lure the biosciences."[13] Common sense dictates that at least some of these states face an uphill battle as they compete with others that are better prepared to attract talent and money.

States shouldn't be lemmings, following the crowd to an uncertain future. They must strategically choose areas most likely to pay off in new or expanding businesses, a well-educated workforce and high-paying jobs. It's not enough to find opportunities for marginal gains. The goal is to overwhelm the competition by being the pioneer, the champion or the only player.

Research in this field shows that building on existing intellectual strengths in both academic and business sectors is critical, as is making certain there's a cluster of relevant local businesses to take advantage of the benefits of newly developed knowledge. Undertaking research in fields for which there are no local firms is likely to directly benefit other states that have the appropriate corporate infrastructure in place.

One key to industry's heart is to persuade business leaders that there's something of value for them in the effort by involving them at the earliest stages. Says Mike Cassidy, president of the Georgia Research Alliance, "Business leaders provide invaluable insight and judgment about the appropriate fields for research investment, and the political support and continuity of vision that are important to sustaining the program over time."[14]

Not only should states look to areas of strength, but also relevance to their particular needs. California, for example, is tackling pollution; no one in the Los Angeles basin would argue that's a bad idea. Iowa, which raises more pigs than any other state, is putting money into research on vaccines for diseases such as the swine influenza virus.

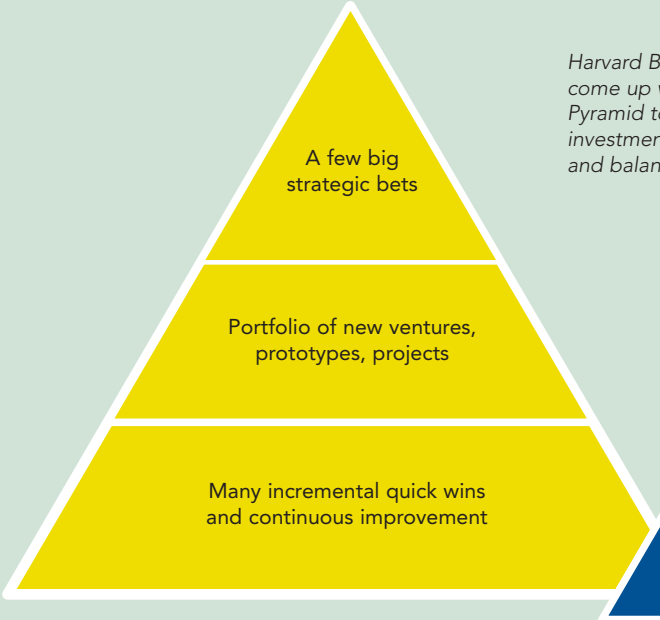
Underlying these concepts is a relatively basic notion: States should invest to preserve, enhance and add—in that order. With that in mind, governors must first ask, "What do we do best and value most that can be preserved?" Next they should consider, "What do we have that should be enhanced?" And the final question is, "What can we sensibly develop that's not already here?"

GOOD RULE OF THUMB

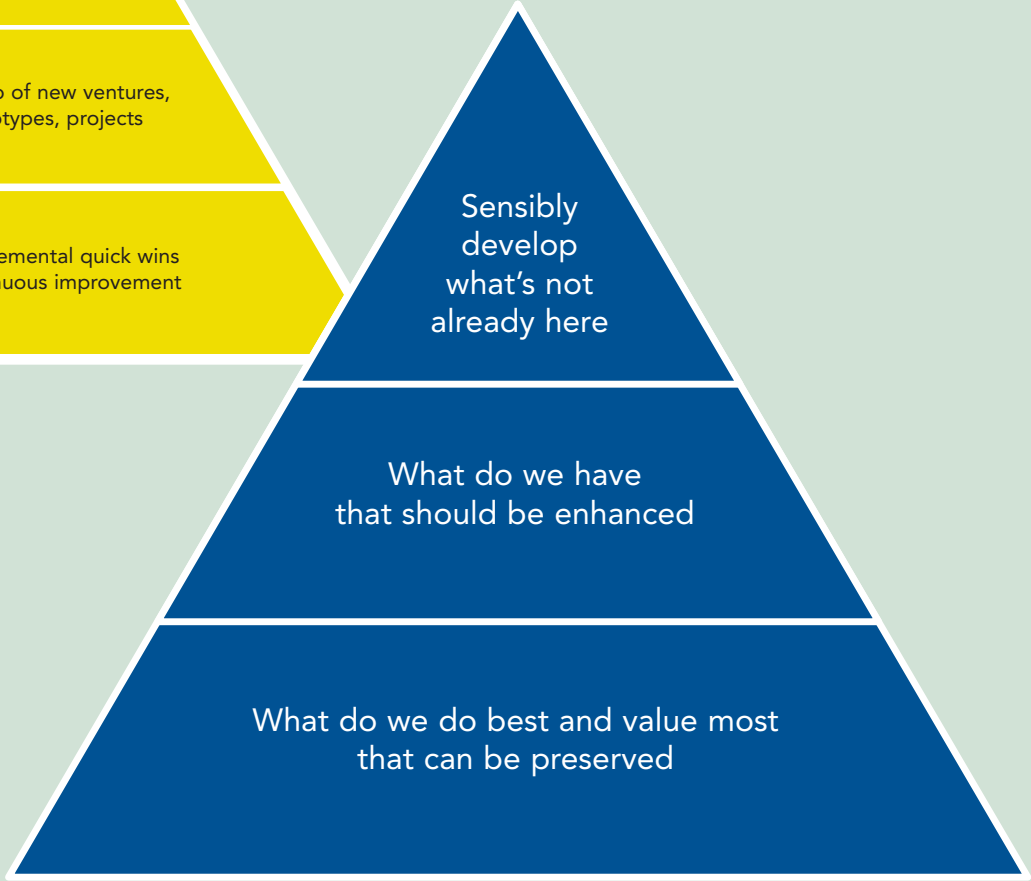
Investment Pyramid

When listed, the preserve, enhance and add investment strategy forms a pyramid. The investment pyramid features a few big gambles at the top, a set of strategic investments to elevate strengths to world-class level around the middle and a broad range of investments to preserve what you do best at the base.

Harvard Business School professor Rosabeth Moss Kanter has come up with a simple strategic tool called the Innovation Pyramid to help winning businesses prioritize and balance their investments.[15] A pyramid is also a tool to help states prioritize and balance research and development investments.



Innovation Pyramid
Source: Rosabeth Moss Kanter



State R & D Investment Pyramid
Source: Pew Center on the States

What States Are Doing

Following are four good tips, based on successful state experiences, for using R&D money to preserve, enhance and add to economic vitality, quality of life and potential for future growth.

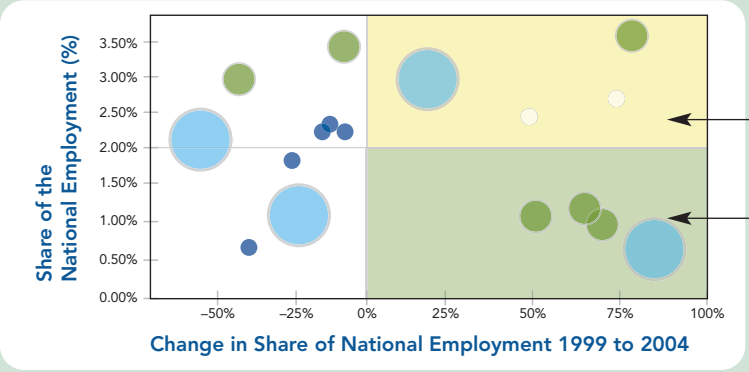
Investing in Strengths:
CORE INDUSTRY CLUSTERS

One of the most successful approaches for states involved in funding R&D has been to target groups of companies and research institutes that are highly concentrated in a state and can feed off one another to become more productive and globally competitive. These "clusters" of strength aren't necessarily self-evident (though they can be), but the effort to identify them has proven worthwhile for a state like Ohio, which has found that cluster analysis can be an excellent guide to investing in areas that matter most to the state economy.[16]

In the early years of this decade, **Ohio** got on the entrance ramp to cluster analysis with a study by Battelle that found the state had a number of clear geographic clusters of strength. The Cleveland area, for example, was ahead of the pack in advanced manufacturing. Cincinnati-Hamilton had residents well-educated in plastics and chemicals. Columbus appeared to have strengths in a number of areas, notably digital services.

Battelle recommended that the state immediately "build world-class R&D stature in areas of

Using Industry Cluster Analysis to Identify R&D Investments



Specialization of State Economy

Each bubble is an industry cluster, and its size is determined by the number of workers in the cluster. Clusters above the horizontal line have more employment than expected for the hypothetical state. Clusters to the right of the vertical line are growing cluster employment faster than in the U.S. as a whole.

In yellow shading, a good place to find: what the state does best and values most that can be preserved.

In green shading, a good place to find: what the state has that can be enhanced.

Source: Diagram based on Monitor Company Group, L.P. and NGA Center for Best Practices state profiles, NGA meeting, February 2007

> "Innovation is probably the single biggest factor determining who succeeds and who fails anywhere in the world."
>
> —Nick Donofrio, IBM Corporation, Global Innovation Outlook, 2007

core competency…in which the state's higher education and private research organizations can excel jointly."[17] One core action item was to establish "Centers of Innovation" to take advantage of pre-existing strengths. In 2003, Ohio's Third Frontier, a 10-year, $1.6 billion effort, established the Wright Centers of Innovation in areas like biosciences and engineering and physical sciences, where at least six organizations have been awarded over $147 million. With guidance from a Third Frontier Commission, the state has also spent more than $50 million to develop a fuel cell industry, more than $100 million on a Biomedical Research and Commercialization Program, and $60 million to create a Global Cardiovascular Innovation Center at the world-renowned Cleveland Clinic Foundation.

Investing in Problem Solving:
BETTER QUALITY OF LIFE

One way in which states create support for research and development investments is by spending money to find solutions to problems high on the public radar such as chronic disease, climate change, and traffic congestion. This approach has another benefit: it helps bind researchers who live in a place to the kind of research being done there.

Delaware is one state that uses community needs to guide its R&D investment decisions. Its incidence rate of invasive cancers is 12th highest in the nation—far out of line with other states in the region. Similarly, Delaware has the 7th highest rate of prostate cancer in the nation. With that in mind, in 1999, then-Governor Tom Carper approved the creation of the Delaware Biotechnology Institute with approximately $22 million in state funding and more than twice that amount in matching support from the University of Delaware and private-sector partners. State investments are credited with bringing in yet another $60 million from the federal government. These investments also helped attract distinguished cancer researchers like Dr. Daniel Carson and Dr. Cindy Farach-Carson, who have tackled the biology of cancer development, biochemistry of bone cells and prostate cancer.

In 2006, Governor Ruth Ann Minner established the Delaware Science and Technology Council. The council supported a $360,000 request to create a Center for Translational Cancer Research—a partnership of the Biotechnology Institute, the University of Delaware, the Christiana Care Helen F. Graham Cancer Center, and the Nemours/A.I. duPont Hospital for Children. One of the center's goals is to unite local cancer researchers and clinicians with a common focus on developing new cancer treatments or identifying new cancer biomarkers for population screening, prevention and risk management.

Investing in a Niche:
UNIQUELY YOURS

Many states are funding stem cell research initiatives. Sometimes, though, it can be a little difficult to tell these various efforts apart. A growing body of experts argues that whether states are able to carve out a specific niche in fields such as this one is an important factor in determining which states will yield a higher return on their investments. **Maryland** is taking this advice seriously.

The state took great care in looking at the vast menu of research possibilities that fall under the broad rubric of stem cell research. In addition to investing in basic research, it strategically targets funding for translational research, often referred to as the "bench to bedside" part of biosciences R&D, and research that involves new hypotheses, approaches, mechanisms or models that may differ from current thinking—and unlikely to ever

Investment Tips Trickle Up in Kansas

When states look for opportunities in R&D, they are wise to start with the work being done in their own metropolitan areas.

Kansas, for example, has been building on the strength of a bioscience sector that was already in bloom in Kansas City. With an endowment of approximately $2 billion from a large charitable donation, the Stowers Institute for Medical Research was opened in 2000 and has since developed into one of the nation's leading biomedical research institutes. Around the same time, local stakeholders formed the non-profit Kansas City Area Life Sciences Institute to seed small research grants and serve as a "broker, facilitator and matchmaker"[18] designed to turn the Kansas City region into a world-class life sciences hub.

These local investments and the support of the Kansas Technology Enterprise Corporation catalyzed a renaissance in state investment in the biosciences.

In 2001, the legislature authorized about $130 million in bonds to finance improvement of bioscience facilities at universities. In 2004, it authorized about $500 million more over the next decade to create the Kansas Biosciences Authority. The authority funds research matching grants, infrastructure improvements, and an eminent scholars program that seeks to attract world-class scientists. The authority recently launched a major effort to attract a national biotechnology and agricultural defense laboratory.

be funded by the federal government. In 2006, the state legislature authorized $15 million for the Stem Cell Research Fund, to be managed by the Maryland Technology Development Corporation (TEDCO) through a 15-member commission with representatives from academia, hospitals, patient advocacy groups and industry.

The legislative language creating the research fund is explicit about the link to economic development, noting that the program seeks to retain and attract scientists in the field, build upon existing research strengths, develop and accelerate new developments for patient health, and capture economic development benefits from the nascent industry development around stem cell research.

The translational focus is clearly spelled out in the approach to reviewing applications. Those reviews not only focus on the applications' scientific merit, but also pay special attention to the potential for the advancement of biotechnology in Maryland, the extent to which collaborations are evident between basic and preclinical components, and the existence of plans to transfer potential findings from basic research to preclinical studies.

The R&D experience of **North Dakota** is proof positive that finding a niche—in this instance surface protection—and succeeding flows from strategic thinking and a solid R&D foundation.

The state began building a foundation for success around 2000, when a lackluster higher education assessment and a public-private roundtable on the subject led to a strong commitment from both universities and industry to work to benefit the state's economy. Around the same time, a New Economy Initiative was formed to drive long-term growth.

With the roundtable building support among the governor and legislature, the state invested in centers of excellence at universities that required partnerships and matched funding. To date, $40 million in state investments have leveraged more than $70 million with more than $100 million expected. Collaboration is a key feature of the center initiative.

In the early days, the process wasn't nearly as strategic as it is now, explains Phil Boudjouk, North Dakota State University's (NDSU) vice president for research and a former chemical researcher. "We went to the companies and said, 'What's your next one [project] if you had the money?'" Now, Boudjouk says, the university has a new attitude about research. "We do market-driven research, and it originates with the company, with a problem tied to the market."[19]

One focus area that bloomed from this university-industry collaboration is surface protection (surface coatings to protect the durability of manufactured products), already an area of expertise for NDSU and its well-known Department of Coatings and Polymeric Materials. In 2006, NDSU received a $2 million grant from the state to formally establish the Center of Excellence on Surface Protection, which was matched with $4 million in private-sector investment.

Investing in Emerging Issues:
THE NEXT BIG THING

States don't want to haphazardly jump into cutting-edge technologies, which may not have lasting power. But, with the proper up-front exploration and confidence in future potential, there's a lot of room to creatively pioneer in fields that are relatively new, have the possibility of big payoffs, and need infusions of research and commercial expertise.

Minnesota, for example, has been making progress in renewable resources since 2003. In that year, the legislature mandated work in this area through the Initiative on Renewable Energy and the Environment at the University of Minnesota. The state's goal is to derive 25 percent of its power from renewable sources by 2025.

During the next few years, the initiative invested nearly $19 million in more than 110 research and demonstration projects, leveraged over $12 million in matching funds, including some from business and industry, and collaborated with more than 40 business and industry partners on research.

Similarly, in **Oregon**, the state legislature created the Nanoscience and Microtechnologies Institute (ONAMI) to advance investments in the burgeoning nanotechnology industry.

ONAMI is the state's first Signature Research Center initially funded with an appropriation of $20 million for construction and $1 million for operations. The center is defined by a close operating partnership between the state's three major public research universities, a federal research laboratory and more than 25 "Silicon Forest"[20] high-tech companies.

ONAMI continues to refine its purpose. In the latest year, funding has been used for a combination of signature researcher recruiting ($2.3 million), proposal matching ($1.7 million), facility operations startup ($1.6 million), and intellectual property and proof of concept work ($700,000).

Show Me the Money: How Do States Fund These Investments?

In many different ways:

EARMARKED TAXES – VOTED BY THE PEOPLE

Arizona – Technology and Research Initiative Fund
SOURCE: Proposition 301, a sales tax increase approved by citizens in 2000, earmarks funds to be distributed among the state's three public universities for research, technology transfer and workforce development.
AMOUNT: $1 billion over 20 years.

EARMARKED TAXES – VOTED BY THE LEGISLATURE

West Virginia – Research Challenge Fund
SOURCE: Seeking a stable source of revenue to fund research and development at institutions of higher education, increase competitiveness for external funding, and fund science and math education programs, the West Virginia legislature directed .5 percent of the state's racetrack lottery proceeds to create the Research Challenge Fund.
AMOUNT: Approximately $4 million per year in 2005 and 2006.

GENERAL FUND APPROPRIATION

Georgia – Georgia Research Alliance
SOURCE: Georgia's higher education budget contains resources to fund Georgia Research Alliance activities, including the attraction of eminent scholars, the development of new research facilities and centers for innovation, and the creation of technology transfer programs.
AMOUNT: Approximately $30 million per year (more than $400 million to date).

Kentucky – Research Challenge Trust Fund (Bucks for Brains)
SOURCE: Since 1998, the Kentucky legislature has committed resources to their Bucks for Brains program to attract new talent to the state's flagship universities.
AMOUNT: $110 million in 1998; $120 million in 2000; $120 million in 2005.

TOBACCO SETTLEMENT MONEY

Washington – Life Sciences Discovery Fund
SOURCE: In 2005, Washington created the Life Sciences Discovery Fund, which will begin to tap into tobacco settlement funds in 2008. States such as Arkansas, Connecticut and Oregon are taking a similar approach.
AMOUNT: $350 million; $35 million per year for the next ten years.

TAX INCREMENT FINANCING

Kansas – Emerging Industry Investment Act
SOURCE: Using tax increment financing (advanced funding based on projections of new tax revenue) Kansas is poised to invest new resources in the Kansas Bioscience Authority. The financing comes from growth of state income tax withholdings from employees of bioscience-related companies. State tax revenues that exceed the base year accrue to the authority for making investments.
AMOUNT: An estimated $500 million over the next decade.

BONDS

California – Institute for Regenerative Medicine

SOURCE: In 2004, the voters of California passed Proposition 71 to fund stem cell research by issuing up to $3 billion in bonds. The issuing of bonds was delayed by lawsuits, but a 2007 court ruling confirmed the legality of the approach. Other states are following their lead, with New Jersey set to seek public approval of $450 million for stem cell R&D.

AMOUNT: $350 million in funding per year over a 10-year period.

On the Horizon...

PRIVATIZING STATE ASSETS - A DEVELOPING STATE APPROACH

Two states, **Missouri** and **Indiana**, have considered, but not adopted, privatizing state assets to pay for research and development, facilities improvement and other activities. In Missouri, Governor Matt Blunt proposed partially privatizing the Missouri Higher Education Loan Association in order to raise revenue to improve life sciences research facilities at state universities. In Indiana, Governor Mitch Daniels proposed privatizing the Hoosier Lottery in order to pay for a Brain Gain proposal that would have funded scholarships to attract talented students and supported new research.

And Don't Forget...

PRIVATE AND CORPORATE FOUNDATIONS – A RISING TIDE OF FUNDS

Minnesota – In April 2007, Minnesota's Partnership for Biotechnology and Medical Genomics announced a $5 million gift from the foundation arm of Medica, a Minneapolis-headquartered health insurance company. The funds will support three research projects in cancer and heart disease and two to make research infrastructure improvements in the fields of bioinformatics and obesity.

Indiana – The Indiana-based Lilly Endowment Inc. has committed $100 million to recruit and retain intellectual capital at Indiana colleges and universities and more than $100 million to Indiana University alone since 2000 to expand life sciences research and create the Indiana Genomics Initiative.

Pennsylvania – The Pittsburgh-based Heinz Endowments has long invested in economic development and recently designed a new portfolio of programs titled Innovation Economy with approximately $13 million in funding per year. Grants are focused on educating the next generation of science and technology leaders, especially through community colleges, providing networking opportunities for governments, businesses and universities, and supporting early innovation projects.

GUIDELINE THREE

Invest in collaboration. Innovation is a team sport, with players from universities, industry and government.

"One of the most important lessons executives have learned about innovation in the past few years is that companies shouldn't go it alone," reported *Business Week* in May 2007. "Increasingly, companies are drawing business partners and suppliers into innovation networks. That brings more minds to bear and speeds up product development. Once seen as novel and risky, such external collaborations are now accepted as necessary and even routine ways of doing business."[21]

This concept, already used by many companies, applies to all participants in state R&D enterprises, including academics and government leaders. Despite the virtual closeness enabled by information technology advances, innovation remains a "contact sport," best pursued through personal interactions at every stage in the game.

Governors and their staffs are in a unique position to help R&D funds succeed by encouraging silo busting on a grand scale. One powerful tool is the "open innovation" model. This concept has experienced growing acceptance in the private sector as corporations have realized that it's difficult to ensure that they'll be the ones benefiting from the products of their own research. As a result, the drive to keep research secret is declining in favor of sharing information among multiple players. The expectation, as the table on the next page shows, is that ideas from the outside can be just as useful as ones developed internally and that research doesn't have to be original to be profitable.

As the great industrial labs are being redefined in this way, universities have stepped into a much more central role. "While universities continue to train the next generation of researchers, we also increasingly serve as our society's discovery centers," says MIT President Susan Hockfield. As a result, "the 'upstairs-downstairs' relationship between the academy and industry is over; careers involving both sectors are now commonplace for even our most distinguished faculty."[22] Both the universities and corporations benefit. An inclusive atmosphere brings in wisdom from multiple disciplines in a day when the most important advances flow from the meshing of previously separate fields.

The early adopters of a collaborative approach are likely to gain a competitive advantage. States can head in this direction by steering investment to industry-university collaborations (or even requiring them), building cross-disciplinary centers, and facilitating cooperation between multiple universities. But it may not have to stop there. Some cutting-edge thinkers recommend that states expand collaborative limits by allowing the companies and universities they fund to find partners across state or even national lines.

POSITIONING STATES FOR

An Open Innovation Era

FROM: Closed Innovation Logic	TO: Open Innovation Logic
The smart people in the world work for us.	Not all the smart people in the world work for us, and our customers have ideas, too.
In order to bring new products and services to the market, we must discover and develop them ourselves.	External ideas, when integrated into your architecture, can be as valuable as internal ideas.
If we discover it ourselves, we will get it to market first.	We don't have to originate (and own) the research in order to profit from it.
If you create the most, best ideas in the industry, you will win.	If you make the best use of internal and external ideas, you will win.
We should control our intellectual property (IP), so that our competitors don't profit from our ideas.	We should sell our IP to those who can make good use of it, and we should buy IP whenever it fits our own business model.

Source: Henry W. Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Cambridge: Harvard Business School Press, 2003).

States stand to benefit from open innovation, because it means proximity to knowledge and technical expertise has become more important than ever. Companies jockeying for advantage are likely to be attracted to places that offer critical ingredients for innovation—smart people, research institutions, professional networks, favorable intellectual property agreements and so on. This stands in stark contrast to companies that compete on price, which are known to move great distances in search of lower costs, leading them to China and other developing countries.

What States Are Doing

States are heading in the open innovation direction by using their money to connect silos, encourage cooperation and build partnerships. Here are several examples.

Building Cross-Disciplinary Centers: California

It's not unusual for California to be a pioneer. In its efforts to fund R&D, it was one of the first states to recognize that the nature of innovation had changed dramatically, and that it needed to facilitate open, collaborative and multidisciplinary approaches and encourage normally competitive universities to work together.

Much of the recent publicity for California's R&D funding has gone to its $3 billion, 10-year stem cell research initiative. But that effort is only one of many the Golden State has advanced to bring together public- and private-sector partners. With a dedication to spending big money for mega-centers, as opposed to spreading droplets of cash across hundreds of efforts, the state in 2000 cobbled together more than $1.2 billion of capital for four California Institutes for Science and Innovation. California put up $400 million; private companies contributed much of the rest.

But that's just the beginning. All four centers involve multiple University of California campuses—a precondition for being selected. All are rigorously focused on research that will improve quality of life for Californians and drive economic growth. The four centers already have more than 200 private-sector partners, who are helping them meet a core goal of quickly translating research knowledge and technologies into products that benefit the public.

The four institutions:

CALIFORNIA INSTITUTE FOR QUANTITATIVE BIOMEDICAL RESEARCH (QB3)

Lead campus: UC San Francisco
Cooperating campuses: UC Berkeley and UC Santa Cruz
Using quantitative sciences—mathematics, physics, chemistry and engineering—to increase understanding of complex biological systems, QB3 is focused on finding new cures to improve human health and expanding human understanding of basic biological functions in order to protect and preserve all life. It is also a major training center for more than 140 advanced scientists. QB3 has already worked with dozens of companies, and its Industrial Advisory Board includes Genentech, IBM Health Care and Life Sciences, and others.

CALIFORNIA NANOSYSTEMS INITIATIVE (CNSI)

Lead campus: UCLA
Cooperating campus: UC Santa Barbara
CNSI explores new ways to manufacture products and advance information technology through the exploration of nano-biotechnology, electronics and mechanics. Focus areas include medicine and the environment, and goal innovations include smaller, faster and more efficient computers, lighter and stronger building materials, and light bulbs that use less energy and last longer. The initiative has worked with more than 30 companies.

CALIFORNIA INSTITUTE FOR TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY (CALIT2)

Lead campus: UC San Diego
Cooperating campus: UC Irvine
This multi-disciplinary institute focuses on research and development of prototype technologies to extend the reach and capacity of the Internet, vastly expanding the speed, scope and efficiency of communication in the 21st Century. Advances are expected to have significant and often immediate real-world impacts on California's economy, including the arts, environment, transportation, health care, e-commerce and education. The institute has worked with more than 100 companies, including AT&T, Cox and Sony.

CENTER FOR INFORMATION TECHNOLOGY RESEARCH IN THE INTEREST OF SOCIETY (CITRIS)

Lead campus: UC Berkeley
Cooperating campuses: UC Santa Cruz, UC Davis and UC Merced
This collaborative institute involving four different UC campuses is focused on harnessing information technology to tackle society's most critical needs, including energy, transportation, seismic safety, education, healthcare, farming and the environment. Stated aspirations include, technological innovations to help reduce state energy costs by $8 billion, optimize traffic flows to conserve over 37 million gallons of fuel, and create an emergency network to save lives in the event of a national disaster.

> "In the 21st century, innovation that matters will come from open, collaborative, multi-disciplinary and global engagement."

—IBM Global Innovation Outlook, 2007

Fostering Collaboration Across State Lines

Few states currently collaborate across borders—particularly when those borders require crossing oceans. One reason, of course, is that most states are intent upon getting money to people who reside in their state. But there are certainly instances in which the best partnership options—wherever in the world they occur—leverage the benefits of investment in a significant way.

Consider the February 2007 announcement made by British Petroleum. It is engaging in a $500 million partnership ($50 million per year for 10 years) with the University of California Berkeley, the near-by Lawrence Berkeley National Laboratory and the University of Illinois. Their goal: to create an Energy Biosciences Institute focused on developing clean and sustainable sources of energy and reducing greenhouse gas emissions.

Each partner had something of value to contribute. The University of Illinois, for example, is a global leader in plant genetics. The University of California Berkeley is also a renowned research institution and, what's more, California Governor Arnold Schwarzenegger pledged $40 million in matching funds.

The value of shared expertise was highlighted as a key advantage by Steven Chu, who shared the Nobel Prize in physics in 1997 and is director of Lawrence Berkeley. He noted that the institute would involve as many as 25 teams from different disciplines working together.[23]

Bridging Public "R" and Private "D"

Increasingly, states have become attuned to the idea that the old research and development pipeline model—in which research was phase one, development was phase two, and the two were considered separate entities—no longer functions well. In fact, a number of states haven't just embraced an interactive model—they're even requiring it by insisting on public-private collaboration in proposals.

Take, for example, **Connecticut** and **Maryland**.

CONNECTICUT YANKEE INGENUITY TECHNOLOGY COMPETITION (ESTABLISHED 1985)

Now administered through Connecticut's Clean Energy Fund (a unit of Connecticut Innovations, Inc.), the state's Yankee Ingenuity Technology Competition requires that qualified university researchers apply jointly with eligible businesses and show a "substantial" partnership. Funding in 2007 ($650,000) is focused on proposals addressing commercialization of fuel cell, solar, wind and wave technologies.

Business match requirements include:

	Match of State Funds Required	*Cash or In-Kind*
Large Businesses	100%	At least 50% in cash, remainder in-kind
Small Businesses	Varies; a "substantial contribution" is necessary	At least 25% in cash, remainder in-kind

Matching University Role with Local Economy

Universities can be powerful innovation drivers, and according to a comprehensive project led by the Massachusetts Institute of Technology's Richard Lester, they are most successful when they are attuned to the economic structure of their local economies.[24]

MIT's Local Innovation Systems project has identified four basic types of industrial transformation and key roles for universities in each instance.

Types of Local Industrial Transformation	*Best Role for Universities*
Creating new industries. A new industry emerges that has no prior antecedent in the region. This is often directly related to a spin off of a technology from a university.	Support new business creation, including brokering partnerships among university researchers and entrepreneurs.
Incorporating industries from elsewhere. An industry is new to a region, but it primarily develops through the transplanting of an existing industry to a new location (e.g., development of auto industry in the South).	Provide skilled researchers for the new firms and create a continuing education program for local employees.
Diversifying into related industries. An existing industry goes into decline, but a related industry emerges that can take advantage of the mature industry's core technology (e.g., polymer engineering and manufacturing industry emerges as the tire industry disappeared in Ohio).	Link firms together, sometimes to consider how to apply technologies to their work.
Upgrading existing industries. The application of new production technology that can also lead to the development of new products or services (e.g., firms in mature and service industries integrate electronics and communications technologies into traditional products).	Serve as problem solvers, offering research and consulting support.

University-Industry Partnership Example:
University of Hartford and LiteTrough, LLC; Yankee funds used to improve and test a solar collector for commercialization.

MARYLAND INDUSTRIAL PARTNERSHIP PROGRAM (ESTABLISHED 1987)

The Maryland Industrial Partnership Program (MIPS) is a project of the Maryland Technology Enterprise Institute that jointly funds technology-based research and development between Maryland industries and University of Maryland researchers. Applications come from industry, but must be co-authored by a faculty member. To date, the state has contributed $27.8 million and industry has contributed $115.6 million. The four top-selling products created with MIPS funding grossed an estimated $12.1 billion in sales and revenue in 2006 and created over 2,600 jobs.

University – Industry Partnership Example:
University of Maryland and Blue Wave Semiconductors; MIPS funds used to develop low-cost UV and IR detector fabrics.

Business match requirements include:

	Cash	*In-Kind*
Large and Medium Size Firms	50% of budget contribution	25% of budget
Small Firms	35% of budget	30% of budget
Start-up Firms	10% of budget	35% of budget

GUIDELINE FOUR

Enlist experts.

There are lots of hard **decisions** in this process. You'll need the **best advice** to make them well.

When a state sets up an R&D fund of any kind, a stream of opportunities for investment emerges. Picking the best, with an eye on quality and relevance, must be a competitive process. Otherwise, a fund may create a culture of entitlement in which every university and every region expects its share of the pot.

Both the selection process and subsequent implementation require exceptional people with appropriate abilities. Some of these men and women may already work in state government, but successful investments require many skills often found outside the executive branch or legislature. Among the most significant places in which a governor can place—or insist on having—the best and brightest are:

- On the board or council that sets strategic direction for R&D investments;
- On groups that review proposals competing for money; and
- On groups that select the leaders of the research institutes and academic centers conducting the research.

Input from the private sector is particularly important. Industry drives excellence, and the skills and insights that industry leaders have can help determine the broad fields to explore and the specific projects to fund. Many states use venture capitalists, for instance, to help make judgments about the commercial applicability of specific R&D investments.

Strong academic peer reviewers are also extremely helpful. According to the State Science and Technology Institute, they "ensure that first and foremost the public sector is supporting good science and insulate the selection process from politics to the extent that it can be."[25]

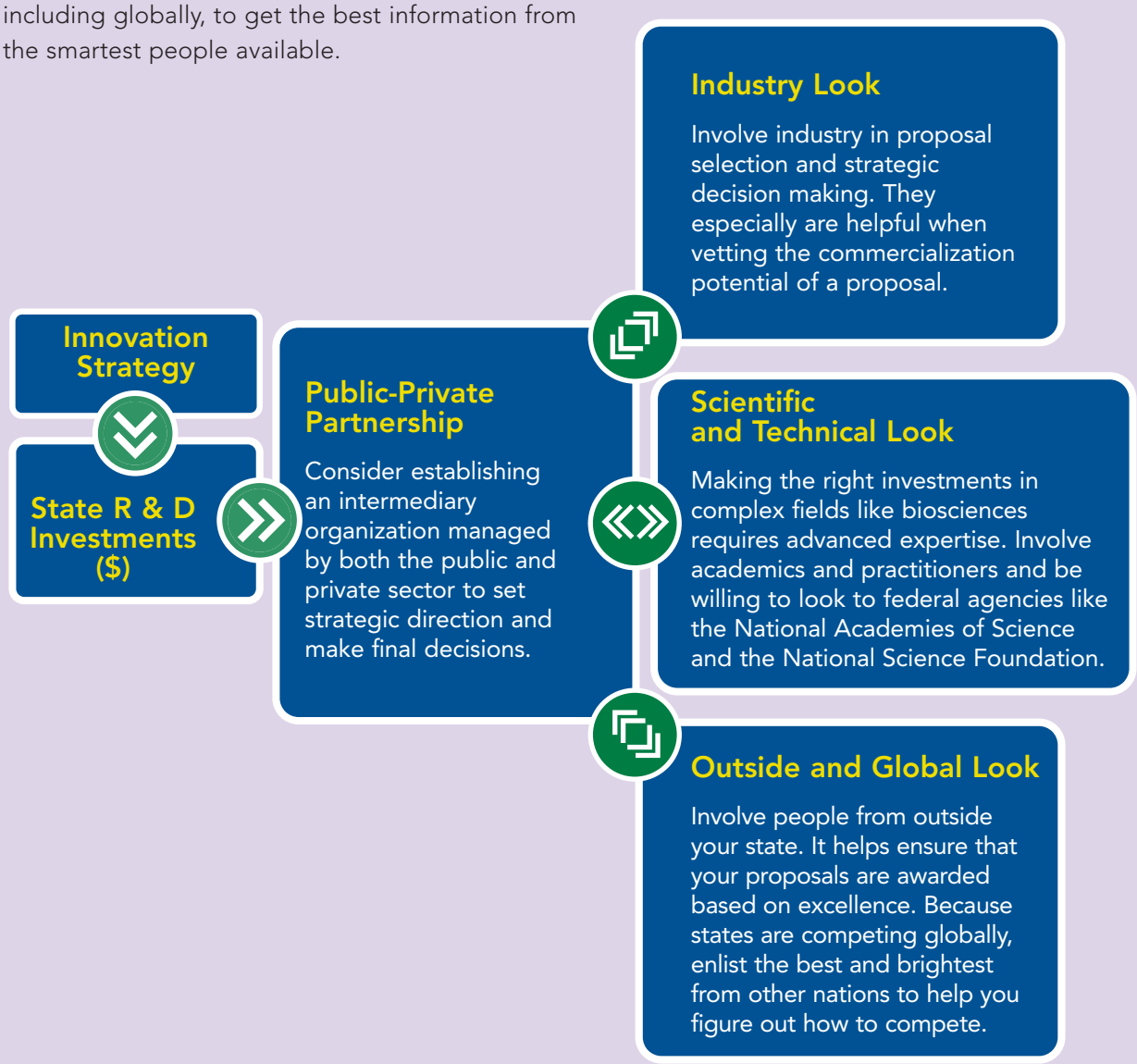
Other factors to take into account in seeking the best and the brightest:

- An international orientation can be critical, as potential competitors aren't just coming from the other 49 states;
- In-state reviewers are easier to find, but having out-of-state reviewers will help avoid parochialism;
- It may be worth considering having a science advisor in the governor's office, to help ensure good choices and continuity of effort; and
- Public-private partnerships can help provide the kind of visibility that leads to public accountability. Burying R&D decision-making—including eminent scholar selections—in the inner recesses of a state agency or university lowers visibility.

GETTING AN

"Outside Look"

The goal is to invest in excellence—not to give a little money to every researcher and every institution. The diagram below outlines an organizational structure and investment process that enlists industry and science and technology experts. States should especially be willing to look outside their borders, including globally, to get the best information from the smartest people available.



Source: Pew Center on the States

What States Are Doing

States are developing mechanisms to ensure that R&D investments are not only strategically focused, but also predicated on merit and excellence.

Enlisting Business Know-How

The **Georgia Research Alliance** has proven one of the most effective vehicles in the nation for making strategic investments in R&D. Mike Cassidy, the alliance's president, attributes much of its effectiveness to engaging business leadership in his state. The men and women who drive private-sector enterprises are invaluable, he says, for providing insight and judgment about appropriate fields for research investment.

And that's just the beginning of the contributions private-sector leaders can make. They also provide:

- Political support and continuity of vision to help sustain the effort over time;
- A focus on the commercialization of research; and
- A deep-seated understanding of some of the basic rules of innovation.

Georgia isn't the only state that has learned how valuable industry can be as a partner. Arizona, New Jersey, Ohio and others have also developed structures that closely align business and public interests.

ARIZONA'S SCIENCE FOUNDATION AZ

Structure: Non-profit, public-private partnership
Industry Leadership: Three statewide CEO groups (Flagstaff 40, Greater Phoenix Leadership, and Southern Arizona Leadership Council) helped found the organization and the Board of Directors includes 12 business and science leaders from Arizona, outside the state and abroad including, Craig Barrett, chairman of the board for Intel and Erich Bloch, a former director of the National Science Foundation and vice president at IBM.

NEW JERSEY'S EDISON INNOVATION FUND

Structure: Public fund operated by the Economic Development Agency (EDA) with investments guided by the Commission on Science and Technology
Industry Leadership: The EDA Board includes, Philip Kirschner, president of the New Jersey Business and Industry Association, and Timothy Carden, a former vice president at Lockheed Martin IMS. The Commission on Science and Technology includes, Richard M. Goldberg, president of the Commerce and Industry Association of New Jersey, and Mario Casabona, a successful entrepreneur now with Honeywell International.

MICHIGAN'S 21ST CENTURY JOBS FUND

Structure: Fund within the private Michigan Economic Development Corporation
Industry Leadership: The 11-member Michigan Strategic Fund Board and the 19-member Strategic Economic Investment and Commercialization (SEIC) Board help administer the fund. The fund board includes, James Herbert, CEO of the Neogen Corporation and Jay Shah, vice president of Somat Engineering. The SEIC includes, Jim Croce, CEO of NextEnergy and John Brown, president and CEO of the Stryker Corporation.

OHIO'S THIRD FRONTIER COMMISSION

Structure: Public entity specifically created by the state legislature in 2003
Industry Leadership: The Third Frontier Commission includes four regional representatives from industry, such as, Richard Fearon, executive vice president of Eaton Corporation. The Commission's 16-member Advisory Board, which provides strategic guidance to the Commission, includes business, university and medical leaders such as, Mark Collar, president of Procter and Gamble Global Pharmaceuticals and Thomas Waltermire, CEO of the private, Cleveland-based economic development organization Team NEO.

Tapping Expert Reviewers

One of the most important benefits of a competitive peer review process through which awards are made on the basis of excellence is that it encourages what University of Nebraska Chancellor James Moeser calls an "entrepreneurial culture."[26] After the **Nebraska** Research Initiative found itself with an uncompetitive process for funding R&D, it established new rules that required all researchers to compete for funding through a clear-cut, transparent peer review process. It also capped funding at no more than four years to encourage programs to become self-supporting.

Some states have sufficient world-class expertise within their borders to create potent peer review panels. **Wisconsin's** newly minted Institutes for Discovery at the University of Wisconsin, for example, drew from the university's multi-disciplinary faculty to screen recent proposals.

California's UC Discovery Grants program relies on California's abundant supply of academic expertise to populate its Field-Specific Executive Committees, which review proposals in biotechnology, communications and networking, digital media, electronics manufacturing and new materials, and information technology for life sciences.

Not all states possess this kind of expertise in the disciplines they are funding and must look outside their borders for assistance. Sometimes, this even sends them to federal government employees for help. **Connecticut, Indiana, Michigan** and **Ohio** all successfully involve out-of-state representatives in their peer review work like the National Academies of Science (who help Ohio's Third Frontier project) and the American Association for the Advancement of Science (who assist Michigan's 21st Century Jobs Fund).

In 2004, **Indiana's** 21st Century Research and Technology Fund received an independent review of its peer review and award process by the firm Partners in Research. The report found that while the fund's review process was "highly independent and unbiased" it should "seek a greater pool of fresh reviewers and set limits on the number of times a person can serve on the review panels."[27] The fund now involves peer reviewers from around the nation with expertise in science and technology, economics and other disciplines.

Wherever the reviewers come from, the benefits of the process are extensive, including:

- Better scientific and technical review;
- Higher chance of commercialization of research;
- Cultivation of an "entrepreneurial" culture as opposed to an "entitlement" culture;
- Inoculation against charges of favoritism; and
- Buy-in for commissioned research by involving more stakeholders in the decision-making process.

Adding Science and Technology Advisors

The president of the United States has an entire council of science and technology advisors and at least 11 states (Arkansas, Idaho, Iowa, Maine, Ohio, Oregon, New Mexico, North Carolina, South Carolina, Utah and Virginia) have individuals who serve governors in a similar capacity, according to the State Science and Technology Institute (SSTI).

New Mexico has a track record of appointing science advisors, most recently naming Los Alamos National Laboratory (LANL) fellow and former LANL chief science officer Thomas J. Bowles to help connect industry and universities and design "better methods to integrate high technology across multiple policy areas."[28]

According to interviews with leading thinkers, having a science and technology advisor may provide a competitive advantage by giving governors:

- Immediate access to scientific and technical advice;
- Connections with networks in other states and globally; and
- A champion to unite science and technology agendas across agencies.

But are they really necessary? Or do they just create an extra layer of needless bureaucracy?

SSTI suggests that each state needs to consider the following factors when making its own determination:[29]

- Complexity of the state's investments;
- Structure of the executive branch;
- Quality of the advisor;
- Relationship to a governor; and
- Power vested in the position.

borrow

"I not only use all the brains I have but all that I can borrow."

—U.S. President Woodrow Wilson

Getting Top R&D Talent On Board

States have to have the best and brightest people in order to become known for Nobel-Prize-level science, top-notch medical care and path-breaking companies. There is no substitute for talent.

How to get top talent on board? Here are several things to consider.

TEN THINGS TO KNOW ABOUT INVESTING IN R&D TALENT

1. **It can be expensive.** The going rate for stars in the scientific world is in the millions and rising. In March, Texas' Emerging Technology Fund announced it was spending $3.5 million to hire Dr. Ravi Sandhu as the founding executive director and chief scientist of the University of Texas at San Antonio Institute for Cyber Security.[30]

2. **But it can be worth the money.** The Georgia Research Alliance has invested in 54 scholars and seen $1 billion in new grants come in, 25 companies launched from scholarly research and 1,500 jobs created at universities.

3. **Talent loves world-class facilities and equipment.** Top scientific researchers need (and are drawn to) first-rate facilities that enhance their work in the same way artists crave the northern light.

4. **Top talent can't be recruited overnight.** Arizona's private Virginia G. Piper Charitable Trust undertook a bold plan in January 2006 to recruit 10 Piper Chairs to support the state's Biosciences Roadmap. One year later the Trust is still working to secure its first chair. This is not an exception—Kathleen Robichaud of the Georgia Research Alliance notes that its average recruitment period early on was three years; refinement of the process has shortened that to 18-24 months.[31]

5. **Star researchers are magnets and mentors for young talent.** Top talent brings young scientists to work with them and may attract hundreds more who want to work with them. This benefit may be one of the most important because many scientists make their greatest discoveries before age 30.

6. **The race for talent is global.** Just as R&D discovery is happening on a global scale, so is the search for talent. Ireland and Singapore are both making global grabs for brains.

7. **Talent is attracted to smart people and smart places.** It seems obvious, but smart people want to be with other smart people and live in places with stimulating non-work environments. That means top-notch entertainment, excellent schools, parks and recreation.

8. **They must work well with others.** Collaboration is a defining feature of innovation and is essential in order to transform valuable research into something valued by the market. Some brilliant researchers are not well-suited for this and may resist working together. No matter what their IQ, this shortcoming can be fatal in an innovation initiative.

9. **The talent race starts early.** Attracting first-rate students with a stated commitment to science and entrepreneurship is an increasingly attractive option for states. With the right incentives, many of these young and talented students may stay within a state for further studies. The career paths of students emerging from California's UC Discovery Grants program, for instance, show they are attractive recruits for California companies. Many of them take leadership roles building new firms in the state.[32]

10. **Growing your own talent is an excellent bet.** In fact, a strong education pipeline, starting with high-quality pre-kindergarten, is an efficient and high-return way to gain talent.

GUIDELINE FIVE

Be consistent while embracing change. Innovation requires sustained effort, but must also evolve with the times.

The innovation imperative—for both companies and economies—isn't a fad. Wise states avoid a flip-flop approach to their R&D investments. They strategically erect structures that will survive new administrations intent on making change for change's sake. They institutionalize the idea of long-term investment so that it can survive economic downturns. Ireland's tenacious approach is a model. It has consistently increased innovation funding and for a decade it has been the fastest growing economy in Europe.

Of course, while consistency is a virtue, inflexibility is not. Enhancement, tweaking, and making changes based on evaluations are important. In today's dynamic of accelerating change and competition, R&D funds must be open to making the best investments possible at every stage.

Long-term funding should never be considered an entitlement, but should instead be contingent on meeting clear-cut goals. If this hurdle is passed, there are a variety of ways to protect the R&D funding stream. Some states, such as Arizona and Washington have gone so far as to earmark funds from pre-determined revenue sources in order to insulate R&D from politics.

Transparency is another key—a large visible fund with a well-publicized mission has greater potential than many small pots of money that can be easily lost in the shuffle.

Other traps to avoid include:

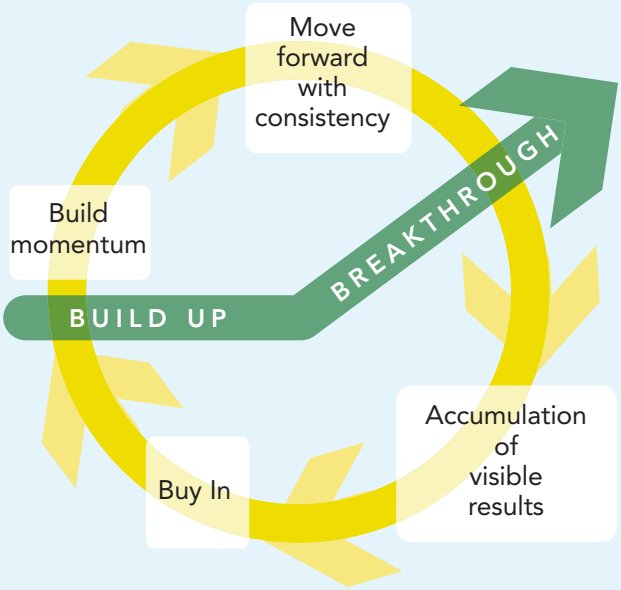
- Politically motivated choices that are vulnerable if an out-of-office party takes control;
- Picking a hot topic that may be lukewarm tomorrow;
- Funding narrow research operations that can be rendered irrelevant if a stronger player enters the field; and
- The temptation to send funds to every region in a state, which can dilute the critical mass necessary for success.

Constituencies for innovation agendas are fundamental. Ongoing funding becomes particularly likely when it has champions in the governor's office and the legislature. Building broader support includes involving business leaders, organizations and potentially foundations in the strategy and design phase. Crucial citizen support can be catalyzed with regular communication to the public through the press and other means. This is easiest when the R&D fund is focused on an issue that is of keen interest to taxpayers. Finally, charismatic, collaborative scientists and center leaders can help by joining community organizations and building partnerships.

THE "PHYSICS" OF GOOD TO GREAT

Consistency vs. Inconsistency

What management guru Jim Collins said about companies can be said about states.

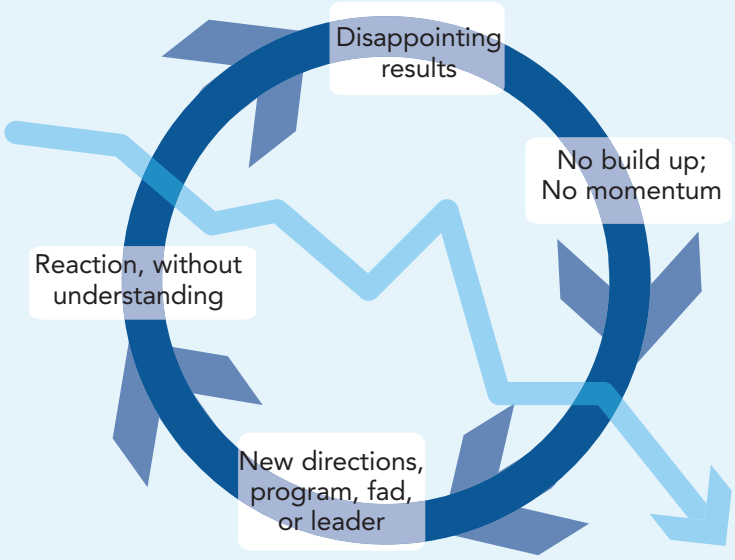


Fly Wheel: CONSISTENCY

"Good to great comes about by a cumulative process—step by step, action by action, decision by decision, turn by turn of the flywheel—that adds up to sustained and spectacular results."

Doom Loop: INCONSISTENCY

Those on the doom loop push in one direction, then stop, change course and throw it in yet another direction—always looking for a miracle moment or big program.



Source: Jim Collins, *Good to Great: Why Some Companies Make the Leap…and Others Don't* (New York: HarperCollins, 2001).

What States—and Countries—Are Doing

For generations, the United States barely considered the rest of the world when it came to economic development. Only with the arrival of well-made, big-selling cars from Japan and Germany did the concept of international competition start to become a reality. Now, it's a reality that can't be ignored. Nations like Ireland, Finland and Singapore are sustaining big bold strategic initiatives for R&D and innovation and they're paying off. Only with sustained, yet flexible, investment in areas of strength, will the United States be able to hold its own in the global marketplace.

Ireland, Finland and Singapore

Ireland, Finland and Singapore, countries that are similar in size to many American states, are not leaving the development of innovation to chance—they are making a concerted, consistent effort to make it happen. Here, some highlights of their stories:

IRELAND

In the 1990s, Ireland redirected its faltering economy away from farming and manufacturing toward technology and services. As a major part of that process, the country began strategically investing in research and development. Three government agencies share responsibility for growing the country's knowledge-based economy and work together to ensure great ideas are not wasted. Enterprise Ireland works to transform Irish industry; IDA Ireland secures foreign investment that in 2006 hit $635 million U.S.; and Science Foundation Ireland (SFI) links industrial and academic research.

SFI emerged from the country's 2000 to 2006 National Development Plan with more than $700 million to fund research projects. In just a few years, SFI has become a prime example of Ireland's R&D success, bankrolling more than 1,000 projects and helping to attract 2,500 research scholars. Hundreds of international companies, including Dell, Microsoft, Intel and Motorola, now have operations in Ireland and have established research partnerships with Irish universities.

Ireland is now one of the world's most dynamic economies, but it is not resting easy. Its newest six-year National Development Plan continues the country's steadily increasing investment in

R&D and includes $35 billion for human capital development and another $27 billion for enterprise, science and innovation, $1.9 billion of which SFI will invest in new research opportunities.

FINLAND

Finland's 7 percent unemployment rate may still be high compared to some countries, but it's a vast improvement over the country's 1994 peak of 16.6 percent. Since then, the country has dramatically ramped up research and development spending. Finland spent $7.7 billion on R&D in 2006, an increase of 235 percent since 1990. Government and businesses alike have steadily increased their investments, with government spending comprising a third of national R&D expenditures.

As in Ireland, three Finnish organizations carry out their R&D strategy. Sitra, the Finnish national fund for research and development, can thank Nokia, the cell phone manufacturer, for providing the bulk of its $1 billion endowment, which it uses to supply venture capital to Finnish start-ups. Tekes, Finland's national technology agency, supports university- and business-based research; its budget tops $650 million, which it uses to fund more than 2,000 projects annually. Additionally, the Finnish Academy of Science and Letters funds centers of excellence with a focus on science.

Finland's strategy has paid off. Their GDP grew 3.4 percent in 2006, up from 2 percent in 1990, and the number of college graduates has nearly doubled over the past two decades. By 2005, the country climbed to the top of the World Economic Forum's Global Competitiveness Index. National leaders admit, though, that Finland's investment has not translated into as many new innovations, businesses, or jobs as it would like. In the past year, Finland has refocused its attention on broad-based innovation policy and assessing the efficiency and effectiveness of R&D investment.

SINGAPORE

With a GDP equivalent to Oklahoma's, Singapore has successfully used a targeted approach to R&D. In 1991, its first national technology plan invested $1.3 billion in the country's life sciences sector. In 2005, total R&D spending in Singapore hit $3 billion, with private-sector spending comprising two-thirds of that total. While continuing to encourage private-sector investment, the country has committed to doubling its own R&D budget between 2006 and 2011, earmarking $8.9 billion over that time for research-related initiatives.

Singapore is now the world's fifth most competitive economy, with three times as many research scientists and engineers as it had in 1990. It has lured scientists from across the world with its offer of generous funding for their research and the chance to work in the Biopolis, a self-enclosed science city. The country's Agency for Science, Technology and Research (A*STAR), which coordinates public research initiatives, tracks the work of more than 900 scientists in its national researchers database.

The country's consistent commitment to R&D starts at the top. The current five-year plan established a Research, Innovation and Enterprise Council (RIEC), chaired by Singapore's prime minister, and the National Research Foundation, which supports the RIEC and provides coherent national leadership of R&D.

"Ireland gets it. The leadership, regardless of political party affiliation, understood the competition from globalization. They understood they have almost NO natural resources. All they have are people—highly-educated people—and a beautiful place to live. And they understood that if they wanted to seed and nurture wealth and build new businesses and create a high-tech component to their economy, they needed strategic investments."

—William Harris, former CEO, Science Foundation Ireland and current CEO, Science Foundation Arizona, speech in Arizona, September 2006

Taking 8 Big Steps to Create a Biosciences Niche: Arizona

Since the late 1990s, Arizona has strategically focused on building an innovation-oriented research enterprise, based on its existing and emerging clusters of strength. It has climbed ever upward toward this goal with each major accomplishment building on those that preceded it.

Late 1990s: Industry clusters – In the midst of a real estate crash in the late 1990s, Arizona—and its three big regions Phoenix, Tucson and Flagstaff—targets export-oriented, knowledge-intensive clusters to build regional strengths in high technology, software, biomedical, aerospace and advanced financial services. All these sectors can deliver high-income jobs and propel other development.

2000: Arizona university research – Citizens approve Proposition 301 which earmarks $1 billion in sales tax increases over 20 years to be distributed among three public universities to expand external funding for research, technology transfer and new business development. All three universities align their research focus with key industry clusters in their region. Citizens recognize that top-tier universities are a critical infrastructure for the 21st century.

2002: Arizona Biosciences Road Map – The Flinn Foundation hires industry analysts Battelle Memorial Institute to develop a road map to scale up Arizona's efforts and activities over the next five years in three areas of existing or emerging biosciences strengths: cancer therapeutics, neurological sciences and bioengineering.

2002: Genomics – $90 million is raised to jump-start the bioscience industry by bringing star genomics researchers to the state and creating new not-for-profit Translational Genomics Research Institute (TGen) to expand upon and translate the discoveries of the Human Genome Project and other systemic sequencing efforts into advances in health care.

2003: Research facilities – The Arizona legislature approves $440 million in research facilities at the state's three public universities. The universities use the new support for activities such as the Biodesign Institute at Arizona State University, BIO5 at The University of Arizona and the Strategic Alliance for Bioscience Research and Education at Northern Arizona University.

2004: Community colleges – Maricopa Community Colleges targets more than $100 million of a voter-approved bond package for bioscience and health care training.

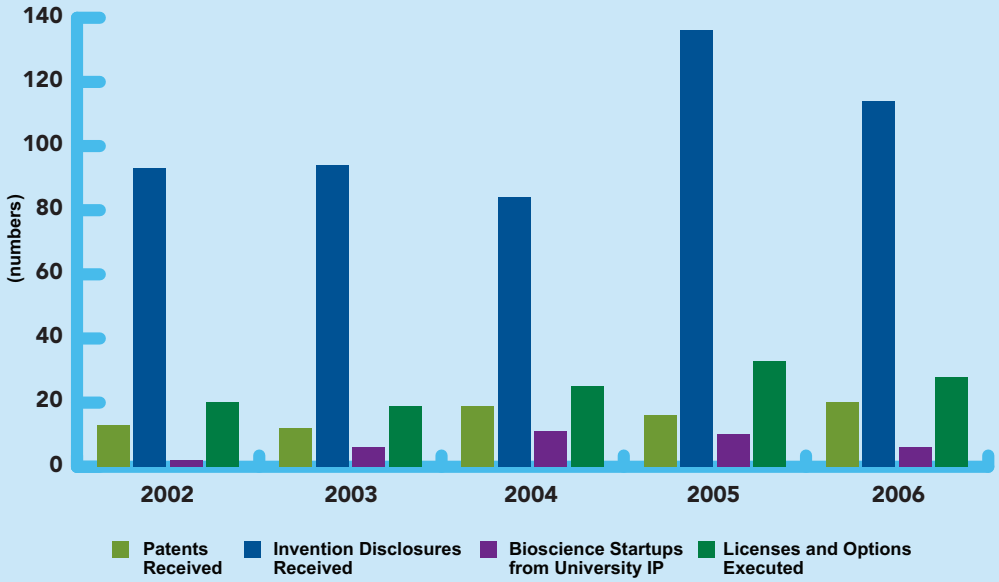
2006: Science Foundation Arizona – Business, state and foundation leaders establish a public-private fund supported by $270 million in state funding and private contributions to support science and technology research and attract top-notch research talent to Arizona's universities and research institutes.

2006: Personalized medicine – The Virginia G. Piper Foundation creates a $50 million fund to attract world-class scientists, engineers, researchers, and physicians to Arizona's public universities, research institutes, and medical centers. The goal: to make Arizona a pioneer in personalized medicine.

Ongoing: Outcomes tracked to economic growth – Arizona's progress in meeting its Bioscience Roadmap goals is being consistently tracked. A December 2006 evaluation by Battelle Technology Partnership Practice finds that key inputs such as academic R&D expenditures are up 23.4 percent from 2002 to 2004 and that key outcomes such as patents issued are up from 13 in 2002 to 20 in 2006. Overall, nearly 84 percent of Roadmap actions showed progress.[33]

Arizona's R&D Investments

With State Support, Arizona Universities Post Gains in Key Indicators of Innovation



Source: Battelle Memorial Institute, "2006 Arizona's Bioscience Roadmap Progress Report" (Technology Partnership Practice, December 2006).
Notes: Invention disclosures (IDEs) are usually the first step inventors take to formally disclose inventions to sponsoring institutions and initiate the complex patent protection process. IDEs therefore reflect initial ideas with commercial potential. Licenses/options executed provide a vehicle for the transfer of intellectual property from universities to companies that will commercialize the technology.

Sustaining the Effort: New York

In the world of state R&D investments, a quarter of a century is an almost unheard of amount of time. Though there were a number of experiments in this field dating back to the early 1980s, many have lurched in a variety of directions since—and some still seem to be trying to find their way. But consistency, while a laudable goal, should be combined with flexibility. States that succeed in creating innovation are willing to do the hard work of assessment and implementation again and again and again, in a cycle that often looks like the following:

- Initial state assessment – Figure out your strengths and weaknesses, and lay a solid foundation for the future;
- Targeted investment – Fund your strengths, give your investment reasonable time to mature, and measure your impact;
- Reassessment – Use your measurement findings to reassess your strategic course. Bring in an independent assessor if possible. Tinker or create bold new initiatives if necessary, and figure out whether it's time to up the ante or hold steady. But always be willing to face the brutal facts;
- Reinvestment and revised evaluation indicators – Fund your revised game plan and make sure your measurements match your revised activities and goals; and
- Continued assessment of outcomes – Continue to face the brutal facts.

The efforts to foster research and development in New York have pretty much followed that cycle. A timeline:

1961: The New York Science and Technology Foundation is established within the Department of Commerce to support academic research with commercial potential.

Early 1980s: An assessment shows that universities are New York's major strength – World-class research universities and professors provide a major competitive advantage over other states.

1983: Five Centers of Advanced Technology (CATS), including the Syracuse University-based Computer Applications and Software Engineering Center, are created at major research institutions to support university-industry collaboration in commercially relevant technology areas. The regional CAT proposals are peer reviewed by the National Research Council.

1986: An independent study shows that the best centers are connected to industry clusters and finds that the greatest return on investment was achieved where universities matched their research focus with industry strengths in their regions.

1987: Centers refocused to connect with industry and economic growth – The centers were refocused on commercialization through enhanced monitoring and the creation of the CAT Development Program.

1999: New York creates the New York State Foundation for Science, Technology and Innovation (now called NYSTAR) and redesigns its science and technology programs. With an annual budget of $120 million, NYSTAR invests in research universities through faculty development ($7.5 million), capital facilities ($95 million), technology transfer incentives ($4.7 million) and

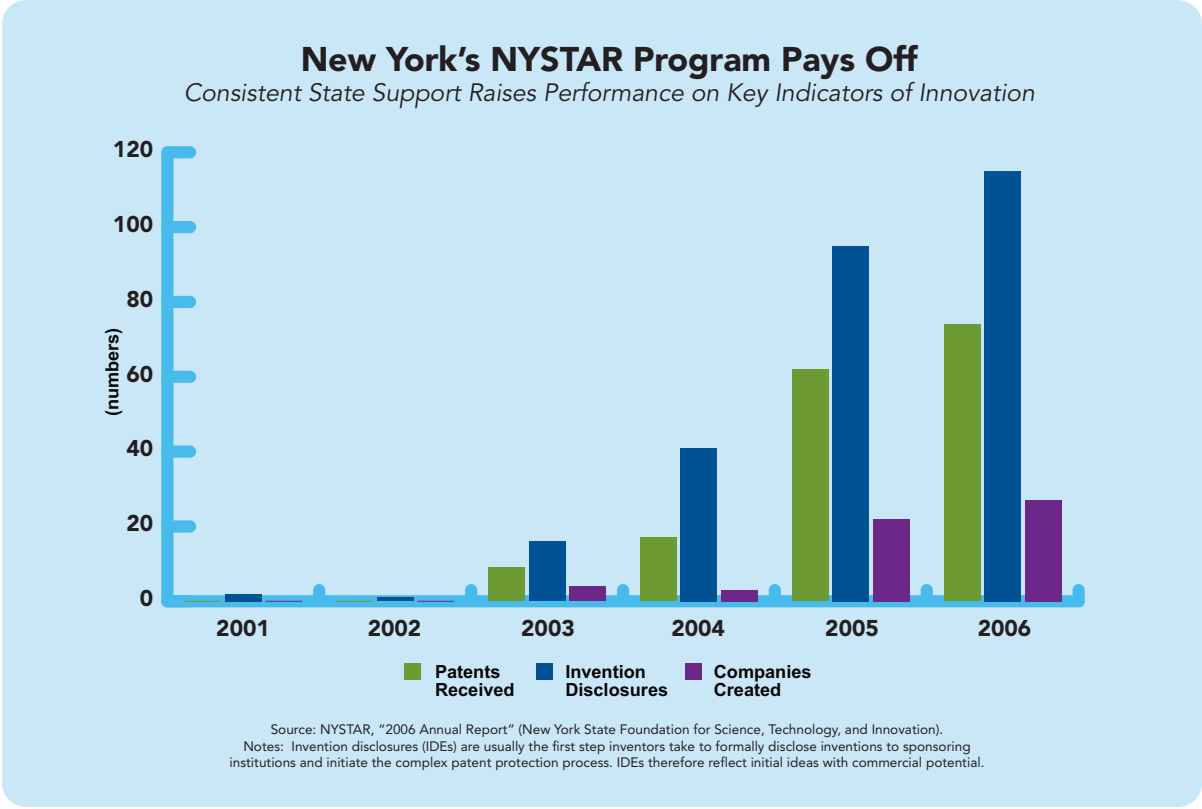
$10 million for a program to expand the capacity of CATs that work in targeted technology areas such as integrated electronics, optics, biotechnology, telecommunications, robotics and automation, imaging and nanotechnology.

2001: New York announces a $1 billion science and technology and biotechnology plan that leads to major investments in bioinformatics, structural biology and nanotechnology through the eight STAR centers (Strategically Targeted Academic Research) at a cost of $15 million per center.

2002: The Albany Center for Excellence in Nanoelectronics is given more than $100 million in state funds to open one of the world's most advanced chip-making R&D facility (public and private costs, approximately $2.5 billion). One year later, International SEMATECH agrees to site its next generation computation R&D center near the nanoelectronics center.

2006: The New York Institute for Stem Cell Research and Regenerative Medicine is established. In 2007, new Governor Eliot Spitzer pledges $1 billion over 10 years for the institute.

Ongoing: Outcomes are tracked to economic growth – Through approximately $240 million in investments (including, $81.8 million for applied research through academic R&D centers and $51.8 million for "frontier" science at academic R&D centers) New York estimates more than $5.8 billion in economic impact from 2001 to 2006.[34]



GUIDELINE SIX

Measure results. It isn't easy– but it is critical to success.

Even when states do everything right with their R&D funds, it can be a long while before scientists can point to an actual product that had its genesis in their work. Experience with state programs suggests that immediate job creation is unlikely, and even successful research will take at least 10 to 20 years to bear economic fruit. This is, of course, no different from the time span required in exclusively private-sector enterprises. For example, it takes at least 15 years for most new drugs to move from discovery to patent.

Of course, R&D funds can't simply continue to pour public money into investments with little more than faith and reassurances from the parties involved. This is why they must regularly measure the results of their investments—ideally along a continuum. At the outset of the process, it makes sense to measure short-term results, like scientific papers published, grants awarded and partnerships seeded. Somewhat further along, the focus can shift to more tangible results, like higher-paying jobs, new industries and innovation outputs.

Measuring the performance of R&D funds is not a refined science by any means. A number of important elements of successful R&D are particularly difficult to measure. How, for example, can a state determine the quality of collaboration or the ease with which networks operate?

Even the most obvious measures need to be subject to careful analysis. One measure many states have used, for example, looks at income from patent licensing. But patenting is only one way in which ideas move from innovation to commercial use. So, the National Bureau of Economic Research now argues that a far better approach is to look at the number of innovations developed and the speed with which they are moved into the marketplace.

Fortunately, there are some relatively universal keys to measuring success in R&D investments:

- Measure indirect as well as direct benefits;
- Make sure your measures reflect the specific needs of your state;
- Make the measures public—transparency is critical;
- Have several measures to examine the degree to which research finds its way to the marketplace;
- Secure participation from all stakeholders when deciding what are the right measures;
- Make sure measurement information is produced on a timely basis;
- Don't hesitate to refine and change measures; and
- Consider using an independent reviewer.

MEASURING RESULTS

All Along the Innovation Continuum

Different types of measures are needed along the continuum of innovation. Research success generally involves capturing more research money, talent and prestige, whereas development success involves producing more start-up companies, stronger industry concentrations, higher exports and profits, and new employment opportunities. Too much focus on either end can be counter productive.

RESULTS MEASURED BY:

- Federal grants received
- New R&D facilities formed
- World-renowned talent hired
- Corporate-sponsored contracts
- Research presented and cited
- U.S. patent applications
- Research rankings improved

RESULTS MEASURED BY:

- Industrial interactions
- Industrial collaborations
- Invention disclosures
- Licenses or options
- U.S. patents issued
- Venture investments formed

RESULTS MEASURED BY:

- New companies formed
- Industry concentration increased
- Companies retained/attracted
- Employment opportunities increased
- Graduate students hired in state
- Old Industry transformed
- New Industry specialization
- "State dividend" realized: apply science and technology to real and immediate concerns of residents; receive direct benefits (reduced air pollution, access to top medical care, etc.)

Source: Pew Center on the States

What States Are Doing

Just as a private company must measure profit and loss, states must find their own performance measures to make sure that R&D funds are delivering promised benefits—and make adjustments where necessary. As shown in the table to the left, this must be done at all stages of the exercise.

A handful of states are leading the way in developing effective performance measures for R&D funds. Three that are rigorously tracking their spectrum of R&D investments are Arizona, Maine, and Georgia. And Massachusetts is an example of a state tracking progress in all of the innovation pieces, not just R&D investments. Even the leaders still have room to grow, in looking at some important elements that are hard to measure, such as collaboration.

> "Creativity—generating ideas—is relatively easy. Innovation—putting them to work—is far more difficult."

—Theodore Levitt, "Creativity Is Not Enough," Harvard Business Review, Executive Edition, Spring 2007

Arizona State University's CAT Measures

"The CAT [Connections, Attention and Talent] Measures tool will help state policymakers determine whether public investments in science and technology research are likely to pay off. They often have to make decisions in an environment of uncertainty, particularly when it comes to long-term economic strategies. The CAT Measures are designed to inform policymakers along the way by providing ongoing feedback on the impacts of research activities."

– Rick Heffernon, Senior Research Analyst, Morrison Institute for Public Policy[35]

How They Measure

Proposition 301 research and development funds going to Arizona State University (ASU) are measured on the basis of three categories:

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; and

TALENT – The top scientists, students and technically skilled workers who help make a region fertile ground for research, innovation, entrepreneurship, and economic growth.

What They Found

The Morrison Institute for Public Policy at ASU recently published a study[36] which shows:

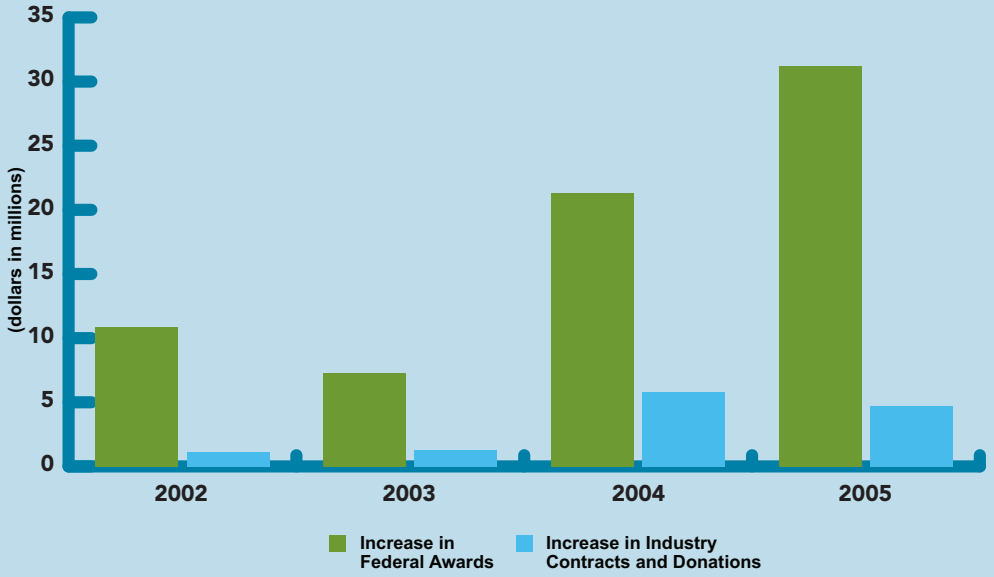
- New research grants from federal sources rose from $8.2 million in 2001 to $21.7 million in 2005; and
- Income from licenses and royalties on patents rose from $68,000 in 2001 to $893,000 in 2005.

- Papers published by researchers rose from 126 in 2001 to 231 in 2005; and
- Citations by non-ASU researchers of published papers rose from 15 in 2001 to 2,432 in 2005.

- Salaries of recently degreed graduate students (as a percentage of national salaries) rose from 95 percent in 2001 to 103 percent in 2005; and
- Researchers with major honors rose from 1 in 2001 to 4 in 2005.

Arizona State University's R&D Investments Draw Increased Federal and Industry Support

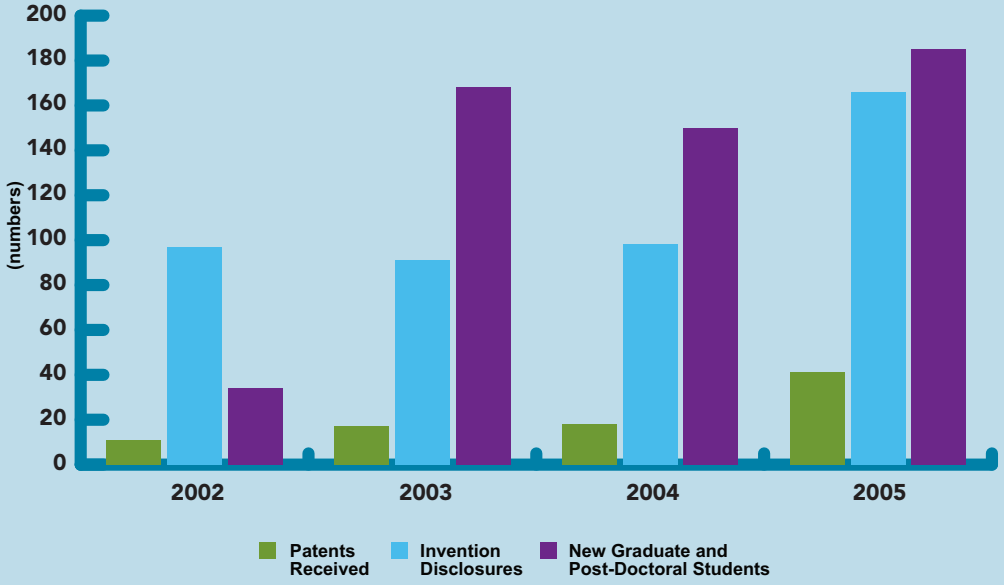
Measures Show Annual Growth in External Funding Triples from $12 Million to $36 Million



Source: Morrison Institute for Public Policy at Arizona State University, "Enriching Arizona's Knowledge Economy: Creating the Research Connections, Attention, and Talent Arizona Needs to Compete; Proposition 301 at Arizona State University, FY 2002 - FY 2005," http://www.asu.edu/copp/morrison/cat2006.htm (accessed June 27, 2007).

Arizona State University's R&D Investments Pay Off

With State Support, Measures Show Large Gains in Key Indicators of Innovation



Source: Morrison Institute for Public Policy at Arizona State University, "Enriching Arizona's Knowledge Economy: Creating the Research Connections, Attention, and Talent Arizona Needs to Compete; Proposition 301 at Arizona State University, FY 2002 - FY 2005," http://www.asu.edu/copp/morrison/cat2006.htm (accessed June 27, 2007).
Notes: Invention disclosures (IDEs) are usually the first step inventors take to formally disclose inventions to sponsoring institutions and initiate the complex patent protection process. IDEs therefore reflect initial ideas with commercial potential.

Maine's Questions and Answers

Our measures say "We need to invest more in R&D, it's not that complicated. We made a big ramp-up, and you have to keep priming the pump. We need projects that are industry-led, that pull on our really excellent research institutions."

– Catherine Renault, director of Maine's Office of Innovation[37]

How They Measure

Building on previously outlined goals and several strategic plans including the 2005 Science and Technology Action Plan for Maine, a recent independent evaluation asked:

- Overall, has Maine's public investment in research and development stimulated and sustained consistent, competitive growth in its economy, especially when compared to other states?
- Has Maine's investment in public and private university research and development led to increased research capacity, the development of an educated, technically skilled workforce and increased commercialization of university technologies?
- Are Maine's investments in nonprofit research institutions broadening their impact on Maine's economy?
- Is Maine fostering the growth of research-intensive companies, increasing private-sector research and development activity and building a technology-based entrepreneurial community?
- To what extent are these investments increasing the competitiveness of Maine's key strategic technology and industry areas?

What They Found

Maine's Office of Innovation recently received the *Maine Comprehensive Research and Development Evaluation 2006*, an independent evaluation that assessed the impact of more than $296 million in R&D spending since 1996. It was performed by PolicyOne Research (Maine) and RTI International (North Carolina) and included the following findings:

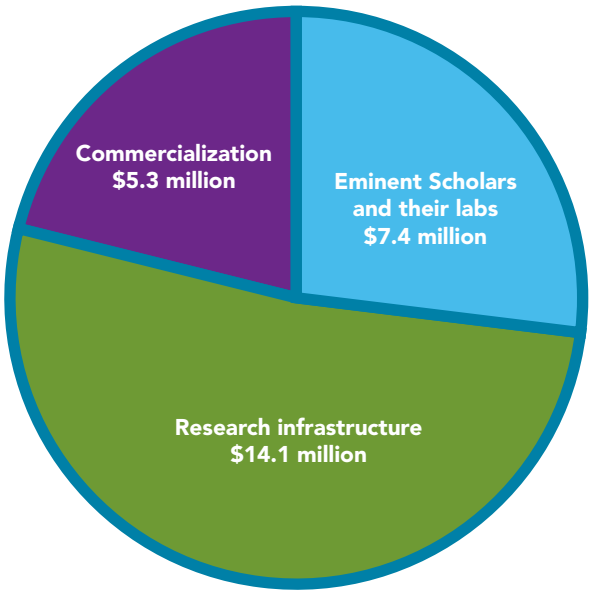
- Maine's investment has "contributed to consistent growth in Maine's economy, and has increased competitiveness relative to other states." The evaluation specifically cites that private sector recipients of funds report higher job growth (6.8 percent) than the rest of the Maine economy (.5 percent);
- While most investments to date have been focused on the academic and nonprofit sectors, they have not been commercializing very much of their new knowledge;
- While investments in the non-profit sector have leveraged more than $32 million through 48 new federal research grants, limited interaction with industry resulted in only $4.1 million in research projects with Maine companies in 2006; and
- The evaluation concluded with multiple recommendations including that Maine invest more in R&D, focus more investments in industry and require more commercialization outcomes from academic and non-profit fund recipients.

Georgia Tracks Investments in Talent

"We help recruit enterprising scientists to Georgia…fuel the launch of companies that create high-value jobs…and broker working partnerships between businesses and universities."

— *Georgia Research Alliance, The Year in Opportunities, a Report to Constituents 2006*

GEORGIA RESEARCH ALLIANCE INVESTS HEAVILY IN EMINENT SCHOLARS...



Total
$26.8 million

...YIELDING THESE DIVIDENDS SO FAR.

54	Scholars recruited
18	New nationally recognized Centers of Research Excellence
$2 billion	Federal and private investment leveraged
100+	Existing corporations served by university partnerships
125	Companies created
4,000+	Jobs created

Source: Georgia Research Alliance, "The Year in Opportunities, A Report to Constituents 2006" (2006).

Massachusetts Innovation Index

"Innovation is a complex process. No economic model can do full justice to the interplay of talent, finance and new ideas that determine first whether an innovation will occur, and then if it succeeds in generating real economic growth. The objective of the Index is to create a broad outline of the innovation process in the economy so we can benchmark the Innovation Economy in Massachusetts with other competitor states to identify trends in the leading indicators over time."

2004 Index of the Massachusetts Innovation Economy[38]

For the last 10 years, the Bay State has annually published the *Index of the Massachusetts Innovation Economy*, an assessment of how well the state performs on 20 economic indicators across 10 key industry clusters. The *Index* also compares Massachusetts' performance with that of nine other leading technology states.[39]

Here's how it works. The 2006 *Index* examined:

10 Industry Clusters

- Computer and communications hardware
- Defense manufacturing and instrumentation
- Health care technology
- Scientific, technical and management services
- Software and communications services
- Postsecondary education
- Textiles and apparel
- Business services
- Diversified industrial support
- Financial services

20 Economic Indicators

Economic Impact (5 indicators):

Industry cluster employment and wages; corporate sales, publicly traded companies; occupations and wages; median household income; manufacturing exports;

Innovation Process (8 indicators):

New business incorporations and business incubators; initial public offerings and mergers and acquisitions; Technology Fast 500 Firms and Inc. 500 Firms; small business innovation research awards; regulatory approval of medical devices and biotechnology drugs; corporate R&D expenditures, publicly traded companies; patent grants, invention disclosures and patent applications; technology licenses and royalties; and

Innovation Potential (7 indicators):

Investment capital; federal academic and health R&D expenditures; intended college majors of high school seniors and dropout rates; public secondary and higher education expenditures and performance; educational attainment and engineering degrees awarded; population growth rate and migration; median price of single-family homes, home ownership rates, and housing starts.

The *Index* produces actionable and nuanced information to guide R&D and other economic development activities. The most recent (2006) report found, for example, both positives…

> "Clear signs that Massachusetts has restored, or at a minimum maintained many of the underpinnings of its innovation economy, including success in attracting R&D dollars, healthy patenting activity, and robust corporate sales figures."

…and negatives…

> "…continued sub-par job growth, relatively low rates of commercialization and high-tech start-ups, and relatively high housing costs"—all factors contributing to workforce issues that "undermines the potential for economic expansion."[40]

The Massachusetts Technology Collaborative produces the annual assessment, drawing from the expertise of the Research and Analysis Advisory Board, which includes members from the Massachusetts Institute of Technology and Harvard University as well as regional representatives from Ernst and Young and other firms.

Other Perspectives on Measurement: What's Your Collaboration Quotient?

Collaboration is a necessary element of innovation-based research, but success isn't easily measured. After years of research on the topic, Technology Transfer Society President Donald Siegel has some ideas. He recommends that states consider tracking the following indicators:[41]

- Co-authored articles published between academic and industry scientists
- Creation of new products, processes and firms
- Cross-discipline centers and research
- Impact on industry commercialization
- Industry-sponsored research investments
- Job mobility of scientists
- Presentations and comparable forms of dissemination
- Productivity of universities in technology transfer

Conclusion

The responsibility for creating valuable R&D investments falls on many shoulders—including the governor, the governor's staff, universities, the private sector and legislators. Without full participation from this array of stakeholders, success may be elusive. But there are a handful of ways that governors are in a unique position to ensure R&D excellence—and many don't necessarily require legislation.

The Key Role of Gubernatorial Leadership

Among the most important ways governors can help is by effectively using their position and its access to the press, the public and powerful players everywhere. Betsy Biemann, president of the Maine Technology Institute sums things up nicely: **"Governors can tell a story of what the future could be," she says. "and help connect the dots."**[42] Any kind of major collaboration on a state-wide level requires a cheerleader, and the governor's desk is the biggest and best place to show the colors of R&D and innovation. This starts with sharing success stories with the public, so citizens can clearly see the connection between these investments and their own economic and social well-being.

Additionally, in the role as chief executive of a state, **governors are singularly able to act in the role of orchestra leader, creating university-university and university-industry partnerships.**

That sounds good on paper, of course, but it requires joining partners that may well be averse to working together. Universities in a state, for example, are often accustomed to competing for grants, competing for students, competing for attention. But they need to be encouraged—or even required—to drop their guards and work together as collaborators toward common goals. The same can be true in encouraging the private sector to join hands with academics. Because there isn't necessarily a natural connection between the two groups, governors can help build those bridges.

Similarly, **governors have an important role to play in encouraging intra- and interstate cooperation**. All the regions in a state, and those that cross state lines, should work together to promote innovation-oriented ventures.

A governor can also require an independent assessment of the state's needs and its R&D trajectory on a regular basis. Consistent measurement will pay lasting dividends by identifying what's working and what isn't, and identifying when a state's investments lurch awkwardly from fad to fad instead of flowing smoothly from opportunity to opportunity.

Finally, **governors are well positioned to require that policy-setting organizations and peer review panels for state R&D investments are benefiting from an outside look, by involving business, economic development and science advisors from outside the state, from the federal government and even from other nations**. Involving outside experts ensures that decisions are made based on excellence and merit, not politics or standard practice.

If a governor did all of these things, brilliantly and with passion, would that guarantee success in the R&D arena? No, but it would greatly improve the odds.

A Checklist of Key Success Factors

Following is a short checklist of some of the other items of consequence a state will likely need to accomplish to heighten chances of long-term success. This checklist isn't inclusive, but it hits a number of the high points contained in the six guidelines offered in this report.

- **The state has put money into projects that fit its particular strengths and needs.** Playing follow-the-leader in R&D means a state may well remain a follower. It's best for states to seek out the clusters of strength that already exist in the private sector and universities and then build on them.
- **Steady sources of funding for innovation investments have been secured.** A variety of means are available to ensure that an R&D investment isn't just the flavor of the week, susceptible to dramatic cuts in the next legislative session. States have used earmarked revenues from tobacco litigation settlements, tax increment financing and other devices. There's no magic to any particular approach—as long as the first check, and the next check and the one after that is assuredly in the mail.
- **Business leaders have been brought into the process at an early stage.** Their counsel and expertise can be crucial to launch R&D projects on the right trajectory. Once the ball gets rolling, they can also be critical in persuading the rest of the private sector to come on board.
- **Innovation has been treated as a long-term process, not a new program.** A short-term strategy is one that uses R&D money as pork for political advantage, makes investments based on what other states are doing and attempts to get funds to every district in a state. That last misstep may seem like equity, but it is actually the kind of sharing that makes the chance of world-class rankings smaller.

- **Universities and private-sector partners are collaborating effectively based on incentives provided by the state.** Research done at the university level will have its best payoff—economically and socially—if industry is prepared to find ways to bring that research to market. That's how great ideas are translated into high-paying jobs, new talent and innovations that benefit the citizenry in a variety of ways.

- **The most creative thinkers—the chemists, engineers, physicists—have the physical infrastructure and professional networks they need to work productively and enjoy a high quality of life in their community.** If this isn't the case, the road to attracting and keeping world-class talent will be pothole-laden.

- **The board or panel overseeing R&D investments draws from a diverse array of experts.** It's an easy trap for a state to call upon a handful of smart insiders to lead the way. But insiders, by definition, have a narrow vision, and the field of innovation leaders is defined by people who see the world through a wide-angle lens.

- **All the parties involved understand that it can take years—even decades—before there is any measurable return on investments.** That's the reality in most cases, and if a state is hoping for a quick payback, it's playing the wrong game. What's more, participants, including legislators, are likely to lose patience if they think like day-traders instead of long-term investors when making R&D decisions.

With these developments in hand, states can rise to the challenge of successful R&D investment. As noted, leadership from the governor's office is critical. The most successful states will be those that select the smartest investments and manage them for long-term impact. Those states will gradually see benefits accrue to their citizens in the form of well-paying jobs and an improved quality of life.

Appendix 1.

METHODOLOGY

Investing in Innovation is grounded in the experiences of states. It is largely the product of extensive document review (including enabling legislation or ballot initiatives; research reports; and organization materials such as fund budgets and evaluations, and newspaper articles) and interviews with leading stakeholders (including, state government employees, legislators, academics, business leaders, university administrators and foundation representatives) in the 50 states from winter 2006 to spring 2007 by a team of experienced consultants (see the acknowledgements section of this report). The report was also informed by conversations with leading academics, private-sector leaders, federal agency employees and others with intimate knowledge of R&D.

In total, this work resulted in the review of more than 100 publications, interviews with more than 150 knowledgeable people across 50 states and the production of more than 300 pages of unique state profiles. This work has been synthesized into the six guidelines and supporting case studies in this report.

Appendix 2.

ENDNOTES

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