Research Benchmarks

Funding University Research Operations and Infrastructure

Report Summary

Rhode Island Economic Policy Council

November 2001

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About the RI Economic Policy Council

The role of the Rhode Island Economic Policy Council is to develop economic policies, based on sound analysis, and to mobilize the resources needed to implement those policies. *A Rhode Island Economic Strategy: 10 Ways to Succeed Without Losing Our Soul,* published in 2001 by the Policy Council, encapsulates the vision to guide economic development initiatives. This research benchmark study is one of the critical projects that emerged to support Rhode Island's Economic Strategy.

Research universities are important in supporting a vital entrepreneurial culture in high technology industries. Research universities produce ideas that can evolve into new products and services, but most importantly research universities are the training ground for scientific and technological innovators of tomorrow.

The Policy Council hopes to stir debate about the benchmarks we want to embrace as goals for building the University of Rhode Island. The University of Rhode Island is a tremendous resource that we can leverage many times over through increased state investment in basic research.

We hope you find these benchmark comparisons to be thought provoking, and we encourage you to share your ideas with the Policy Council by visiting www.ripolicy.org or calling us at 401: 521-3120.

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Abstract

Funding for URI research operations and infrastructure is compared with funding at 133 universities. Adjusted for inflation, total funding for URI research grew 38% from 1980 to 1999; nationally, support grew 139%.

Rhode Island ranks 48th in state funds per capita spent on higher education operations, 50th in percentage of state higher education funds spent on research, and 50th in state funds per capita or state funds per $1000 personal income spent on academic research. In 1999, Rhode Island would have required a $61.7 million annual increase (+43%) to reach the national per capita mean of state funds for higher education operations. A $21.6 million annual increase in State or institutional support would have been needed for university research operations to reach the national per capita mean (+412%).

URI depends more on federal funds for academic research operations than any of 92 public universities in the comparison group. URI spends above average per capita for research in oceanography and psychology, but less than average for engineering, physical sciences, mathematical sciences, computer sciences, life sciences, or social sciences.

URI expenditures on research infrastructure are under national averages and significantly less than top 100 research universities. At least $11 million annually is needed for research building construction, laboratory renovation, and equipment replacement.

Full Report and Data

This is a summary of a consultant's report. The full report and data tables are available at the Policy Council website, www.ripolicy.org.

Introduction

Research Universities nurture the New Economy with leading edge research and copious scientist and engineer graduates. Of ~4000 U.S. colleges and universities, only 125 are Research Universities, yet they graduate 80-88% of the Nation's scientists and engineers holding advanced degrees. Two Research Universities—Brown and URI—are in Rhode Island.

URI is a public land grant University. Its tradition is to provide practical (i.e., economically relevant) education and to conduct research leading to creation of public good. To do this well, URI needs modern research and training facilities, and its faculty must engage in research to keep up with rapidly evolving science and technology.

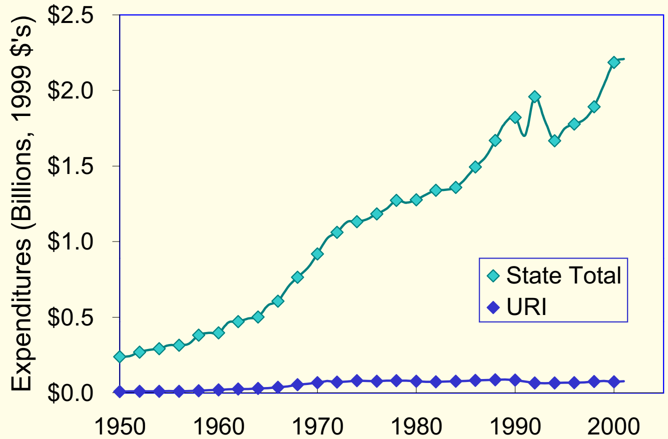
To understand how URI's research capacity compares to other research universities, a benchmark study of funding was conducted for the Rhode Island Economic Policy Council. Benchmark studies look at what similar institutions are doing, seeking standards and practices that can serve as models.

The benchmark study shows that URI's state and institutional funding for research compares poorly with funding in other research universities. The study suggests funding levels that are more appropriate, on a per capita basis, if Rhode Island wants to take advantage of its public research University to help with economic growth. It also provides many examples of successful investments in research, and examples of creative engagements with leading-edge businesses at other research universities.

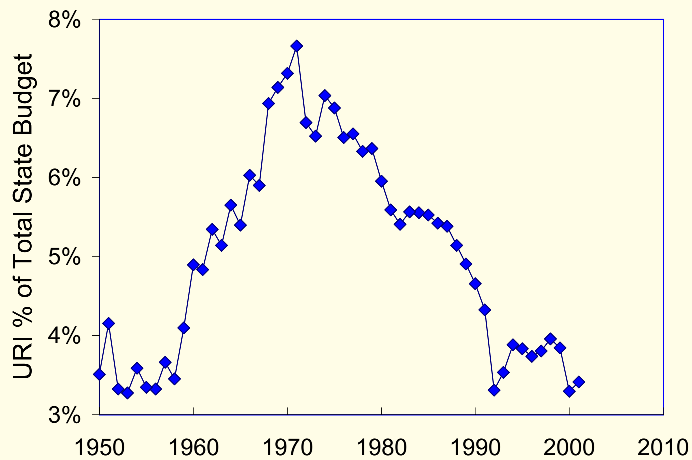
What follows is a summary of critical points from the study. A more detailed version, and a user-accessible database that permits comparison of Rhode Island and URI with other states and universities, is available at the Policy Council web site, www.ripolicy.org.

It is not too late for Rhode Island to catch up. With new investment and with determined leadership at all levels of the University and State government it may be possible to create a science and technology-based entrepreneurial renaissance at URI.

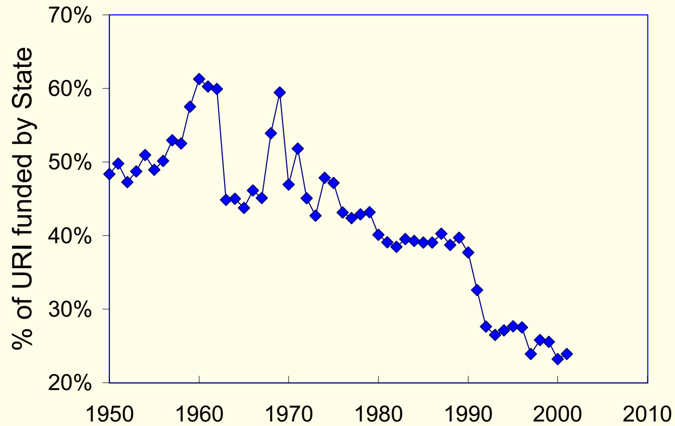
What has happened to URI's research budget?



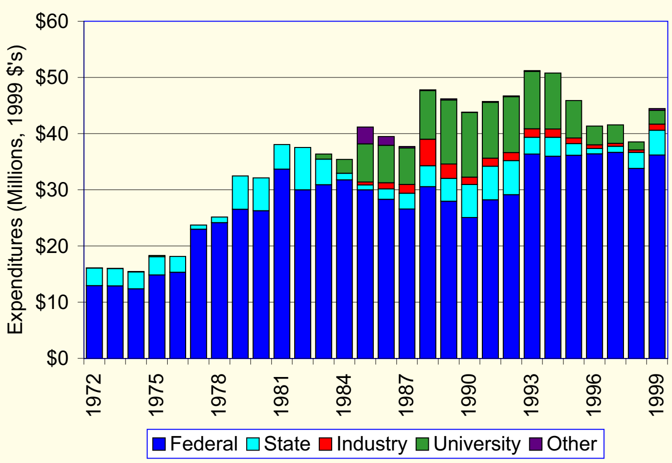
Although State funding for the University grew in the 1960s, by 1971 growth had stopped. URI entered the millennium with 3% less real State support than it had in 1971, even though the State budget had grown by 116%.



With flat funding, URI's budget dropped from 7.7% of the State's total in 1971 to 3.3% in 2000. 2001's budget portion is similar to the 1950s, when URI was the State College, with a third of its present size.



URI has moved from "State University" to "State-assisted University," as the State, which provided more than half of URI's funding in the 1950s and 1960s, provides less than one-quarter today.



Institutional funds for URI research peaked in 1990, but fell 87.5 % by 1998. URI depends more on federal funds for its research than almost all major research universities. While URI research expenditures (from all sources) increased 38 % since 1980, national average expenditures rose 139 %. URI isn't keeping up.

Funding Research Operations

Rhode Island is the geographically smallest state. It is 43rd in population, 44th in gross state product, yet our per capita income is 18th in the nation. By adjusting for population and income, we can compare state and institutional investments to other states and other universities to establish benchmarks for funding university research operations.

State Comparisons

Higher Education. Rhode Island ranked 48th in per capita *state* expenditures on higher education operations in 1999 (does not include expenditures for buildings or equipment, nor funds from tuition): RI's $136.50 compared to a U.S. mean (of 50 states) of $195.38. *If Rhode Island had spent the U.S. per capita average in state funds to support higher education operations, it would have spent an additional $61.7 million.*

University Research. States fund university research with grants from state agencies—to both public and private institutions—and with institutional funds at public institutions. National Science Foundation data on research expenditures (mean 1997 to 1999, in 1999 $'s) show that

- **Rhode Island ranked 50th in % of higher education operating funds spent on research. RI's 3.7 % compared to a U.S. mean (of 50 states) of 13.1 %.**
- **Rhode Island ranked 50th in per capita state support for university research. RI's $5.01 compared to a U.S. mean (of 50 states) of $25.66.** *If Rhode Island had spent the U.S. per capita average in state funds to support university research operations, it would have spent an additional $21.6 million.*
- **Rhode Island ranked 50th in state spending on University research as a fraction of personal income. RI's spending of $0.18 compared to a U.S. mean(of 50 states) of $1.00 per $1000 of personal income.**

University Comparisons

URI was compared to 133 universities, including all Carnegie Research I and II Universities, Land Grant Universities, and 13 Universities regarded by URI as peers. These include 92 public universities and 77 universities with hospitals. Comparison used NSF data on research expenditures in science and engineering, averaged over 1997 to 1999, in 1999 $'s. These institutions spent 84% of U.S. funds for academic research from 1997 to 1999, including 84% of funds from the federal government, 82% from state governments, 81% from industry, 87% from institutional funds, and 79% from other sources.

URI's dependency on federal funds for research. From 1997 to 1999, 86% of URI's research was federally funded: Only six institutions in our sample—including no other public university and no other land grant university—were more dependent on federal funds. No public university or land grant had a smaller percentage of research funds from institutional sources than URI. Adding state grants (52 of the 92 public universities had a higher percentage of funds from state agencies than URI) was insufficient to lift URI or Rhode Island from the bottom rank of state research investments. URI has not significantly compensated with funds from industry: 88 of the other 92 public institutions had a higher percentage of research funds coming from industry.

Benchmarks for Research Operations (Using National Average as Goal)

- **Attaining U.S. mean (of 50 states) per capita state support for higher education operations would require a 43% increase in Rhode Island, or $58.87 per capita ($61.7 million) annually.**
- **Attaining mean (of 50 states) per capita state support for university research operations would require a 412% increase, or $20.65 per capita ($21.6 million of the increase to higher education).**

Public Vs. Private Funding

- Of 688 U.S. universities with expenditures for science and engineering research in 1999, 392 **public** institutions (57%) spent **68%** of total research dollars.
- **State governments** invested in research mostly within their own public institutions, which spent **91%** of state agency grants.
- Public institutions also spent more **institutional** funds (derived from tuition, state appropriations, etc.) on research compared to private (24% vs. 9% of institutional total).
- Private institutions depended more heavily on **federal** funds than public (72 vs. 52% of institutional).
- The distribution of funding sources is affected by status as public or private more than it is by an affiliated **hospital / medical school**.

Funding for Research Operations (From All Sources, by Field)

NSF reports R&D expenditures under major fields—engineering and seven sciences—with sub fields for engineering, and for physical, environmental, life, and social sciences. This includes funds from federal, state, industry, university, and private sources. Compared to national per capita means (U.S. total expenditures/U.S. population),

- URI oceanography has nearly **10** times the mean U.S. per capita funding.
- URI **exceeds** national per capita operational expenditures in environmental sciences (includes oceanography) (355% of national average) and psychology (260%).
- URI is **under** national average per capita operational expenditures in *all* fields of engineering (**24%** of average over all sub fields, with ***no*** expenditures for aeronautics, bioengineering/biomedical, and materials research).
- URI has **low** relative expenditures for mathematical sciences (**0.12%** of national average) and computer sciences (**6%**). The life sciences (**14%** of national average) show low expenditures in biological and medical sciences (**7.5%** and **5.2%** of mean).
- URI's total per capita expenditures for research operations (**$39.62**, 86% from federal sources) are **42%** of the national average of $93.25.

Infrastructure

Maintaining a leading edge in research and graduate education in the sciences and engineering requires constant upgrading of buildings, laboratories, and major items of equipment—collectively, "infrastructure." Major ("fixed") items of equipment—expensive instruments with life expectancies of more than two years—include such things as electron microscopes, robotic gene sequencers, and automatic chemical analyzers. Even expensive and sophisticated instruments are outdated in 3-5 years when technology advances rapidly. State-of-the-art laboratories may require renovation after 15-20 years, and buildings may prove inadequate in only 30 or 40 years, requiring renovation or replacement.

Issues

In the overview to "Scientific and Engineering Research Facilities at Colleges and Universities, 1998," NSF outlines the critical research space issues for the nation. These translate directly into issues for Rhode Island and URI policy makers.

- *How much space is there for conducting S&E (science and engineering) research?*
- *Is this enough space to meet the Nation's S&E research needs?*
- *What is the condition of this space?*
- *How much new S&E space needs to be constructed? How much of the existing S&E space needs repair or renovation?*
- *How much construction and repair/renovation is taking place and what does it cost?*
- *How do colleges, universities, and biomedical institutions fund these capital projects?*
- *How has the situation changed over the past decade?*

Funding Research Infrastructure

For Rhode Island to spur its economy through University research, URI needs to construct new research space, renovate old buildings and laboratories, and replace or upgrade equipment. What are the appropriate funding benchmarks?

Buildings and Laboratories

NSF reports on facilities every two years, summarizing the quantity and quality of research space for science and engineering. "Scientific and Engineering Research Facilities at Colleges and Universities, 1998," published in October 2000, represented 660 colleges and universities. Of these, 57 percent (378) were doctorate-granting, including the "top 100" and "other " institutions, based on R&D expenditures.

Doctorate-granting institutions account for 85% of *instructional and research* space in *all* academic fields, and 91% of *instructional and research* space in *science and engineering*. The top 100 alone account for 71% of research space and 81% of expenditures.

Quantity of research space. Space allocated to research at URI is 56% of the mean for doctorate-granting institutions, and 24% of the top 100. The percentage of instructional and research space allocated to research at URI (38%) is 67% of the mean of doctorate-granting institutions and 60% of the percentage of the top 100.

Distribution of space among science and engineering fields. Research space allocated to Environmental (Earth, Atmospheric, and Ocean) Sciences is proportionately high at URI, as is space for psychology, engineering, and human development sciences. Comparatively smaller proportions of research space are devoted to physical sciences, mathematics and computer sciences, biological and medical sciences, and the remaining social sciences. Space for biological sciences is 4% at URI and 22% nationally.

Adequacy of space. For all fields of science except mathematics, at least half of U.S. institutions report inadequate amounts of space for research. Space for science and engineering research increased 28% from 1988 to 1998, but across all science and engineering fields only 39% of facilities are considered "suitable for use in most scientifically sophisticated research."

URI reflects the national trend. Most of its buildings and laboratories are 30-90 years old and due for renovation or replacement. A URI estimate that 50-70% of space for agriculture, biological science, or medical sciences suits "the most scientifically competitive research" patently overstates quality of space in these fields.

Needed Construction and Renovation. In 1998, URI estimated it needed 85,000 sq. ft. of new research space. The Environmental Biotechnology Initiative (1999) called for construction of an *additional* 85,000 sq. ft . of new core facilities in genomics, transgenics, imaging, and informatics, plus 10,000 sq. ft. of greenhouse space for transgenic plants and 10,000 sq. ft. for a related field house.

In 1998, URI estimated that it had $55 million in needed but unfunded renovations and $0.6 million in new construction needs. The 1999 biotechnology building would add ~ $50 million.

Funding sources for construction and renovation. In 1996/97, U.S. public universities funded S&E research facility renovation from state/local (49%) or institutional funds (27%). URI funded 1996/97 renovations 98% from state and 2% from institutional funds. Nationally, 1996/97 construction used state (47%) and institutional funds (43%—includes 13% private, 13% institutional, and 13% tax-exempt bonds). URI 1996/97 construction used 13% federal and 79% institutional funds (includes private 14%, institutional 8%, and bonds 56%). URI pays debt service on bonds.

Changes over the past decade. U.S. academic research space increased 28% in the last 10 years, but space requiring renovation or replacement increased even faster, in all fields but mathematics. Renovation needs (sq. ft.) in social, medical (outside of medical schools), environmental, agricultural, and biological (outside of medical schools) science more than doubled.

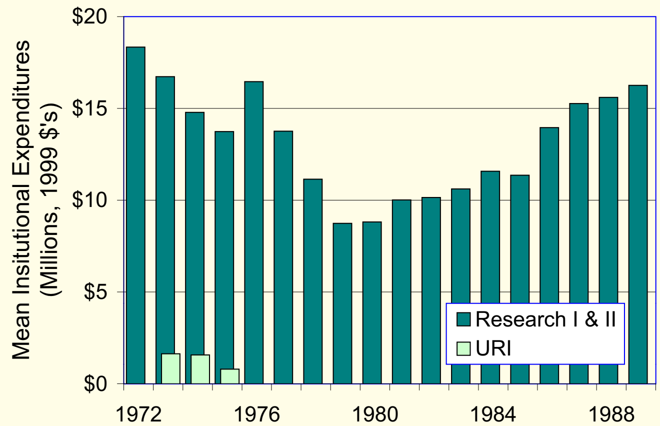
URI renovation averaged $1 million annually from 1996 to 1999, not keeping pace with the $55.5 million in needs. URI's research facilities grew by four projects from 1996 to 2001 (sidebar), creating space in atmospheric, natural resource, and social sciences, and industrial engineering—with no change for other fields.

Equipment

NSF reports institutional data on expenditures for fixed equipment in its "Survey of Scientific and Engineering Expenditures at Universities and Colleges."

Rhode Island ranked **20th** in **total** (all funding sources) per capita spending for equipment during 1997-99. 84% of RI expenditures were from federal sources, compared to 57% nationally. Rhode Island's ***state*** expenditures ($0.83 per capita) were 43% of the national average, ranking it **45th.**

The 1970s and 1980s



Through 1989 NSF published data on research capital expenditures, including construction, renovation, and fixed equipment. From 1972 to 1989, URI capital expenditures were $1.3 million (89% federal), 1.7% of the institutional mean of Carnegie Research I & II Universities.

The 1990s

In the 1990s URI built new research space in the Kirk Applied Engineering Lab, the Cancer Prevention Research Center, the Kingston Campus Coastal Institute Building, and the Center for Atmospheric Chemistry Studies. URI's ***total*** spending for construction and renovation of research space since 1970 remains under the ***annual*** capital spending of many "top 100" universities.

Benchmarks for Infrastructure

Construction and Renovation. Basing benchmarks for state funding for infrastructure on U.S. per capita means—as was suggested for research operations—will not suffice to meet needs. If Rhode Island used national average per capita state investment in construction and renovation as a benchmark, it would spend ~$3.3 million annually for academic research construction and ~$1.1 million annually for renovation. This would permit construction of less than one new science or engineering building every other decade, and it would never clear the $55 million backlog of renovations.

URI needs to eliminate the research infrastructure backlog and to build new laboratories. The benchmark needs to be ***at least*** a doubling of the 1996/97 average renovation and construction figures (i.e., to **$2.2** and **$6.6 million** of state or institutional funds annually), approximately the annual mean figures for the top 100 institutions (i.e., $1.9 and $6.3 million annually). It would also help if the State paid interest on the bonds it uses to fund new construction. These benchmarks would permit a schedule for renovation that better matches the pace of deterioration and would allow construction of a major new facility once each decade.

Equipment. Attaining average per capita state support for fixed research equipment would require a 131% increase (over 1999) to **$2.0 million** annually.

The **total** benchmark for S&E **infrastructure**—comprising construction, renovation, and fixed equipment—would thus be at a minimum ~$11 million annually (~60% for construction, 20% for renovation, and 20% for equipment).

Benchmarks for Research Investment

In a complex state university, many factors inform the research agenda. Faculty, university management, Regents, and State Government may all be involved. At URI, any increased support for research will have to be based on more than simple fiscal benchmarks. Achieving adequate research funding at URI will require vision, leadership, and a plan for the investment.

Natural Advantages. URI possesses some current natural advantages, which it has used to target academic investment in four focus areas—Marine and the Environment; Health; Children, Families, and Communities; and Enterprise and Advanced Technology. More broadly, the Samuel Slater Technology Fund invests in industry-university collaborations based on RI academic strengths in Biomedical Technology, Design Innovation, Environmental Biotechnology, Interactive Technologies, Advanced Manufacturing, and Ocean Technology. These investments are answers to the question, ***"What do our colleges and universities do best now that we can use to build a better University or a better state economy?"***

Future Needs. The long-term interests of the state suggest new questions, ***"What is the future economy that we want? What will we need from our colleges and universities to build that economy? How can we manage state support for academic research and teaching to build what we will need?"***

University faculty currently base their individual research agendas largely on curiosity, value of the research to professional advancement, and external grant opportunities. These may not suffice to entice scientists or engineers to work on the highest priority needs of the future economy. New means may be needed to persuade researchers to respond to long-term needs of the State in an entrepreneurial fashion.

Programmed Research Centers. Researchers are familiar with "programmed research," in which funding agencies require scientists or engineers to respond directly to the goals of the funding agency. Distinct from funds that support curiosity-driven research (a.k.a. "basic" or "disinterested"), an increasing portion of federal funding and virtually all industrial funding is for programmed research. These funds emphasize targeted research *outputs* (i.e., papers, technologies, inventions), and many programs are beginning to also require specific *outcomes* (changes in practice, technology, etc.), involving use of the research by target audiences.

Benchmarking outcome-oriented programmed research in other universities can shape the perspective of State and University policy makers who seek a new approach to investing in URI research. Benchmarks can focus on on-campus research centers, or on on- or near-campus research and technology parks which also support university / industry collaborations.

Research Centers. There are many models for research centers. The National Science Foundation supports several excellent engineering research centers under its programs for Engineering Research Centers (ERC), Industry/University Cooperative Research Centers (I/UCRC), and Materials Research Science and Engineering Centers (MRSEC) (see www.nsf.gov). It is significant that they are ***NSF*** Centers, developed by an agency long known as the champion of ***basic*** science. Their explicit purpose is to encourage collaboration between universities and industry and to support interdisciplinary research on broad topics. Industry contributes about one-third of Center budgets.

Many states support university and industry research collaborations through state-funded research and technology centers, usually at public universities. Private research universities have also entered into notable collaborations (see sidebar on RPI).

Technology Commercialization Centers. Nearly all universities have offices for technology transfer to manage, patent, and license inventions or ideas. The Bayh-Dole Act (1980) gave to federally-funded research universities the rights of ownership and rights to income generated through licensing, with the clear intent to expedite the commercialization of federally financed "intellectual properties." Most universities offer to transfer (i.e., license) rights to develop and sell products of research to external companies.

Other universities commercialize inventions by actively encouraging entrepreneurs through various forms of business incubation or via larger campus-affiliated research parks. The 1999 National Workshop on Research Centers of Excellence, hosted by the Rhode Island Economic Policy Council, described the diverse types of research center organizations, which range from broad to narrow technology focus, and employ an array of approaches to commercialize university research.

The first university-affiliated research and technology park, established by Stanford (1951), led to the "silicon valley." By 1975, there were only 10 parks. Although not always successful in attracting industries, the number of parks has grown. Most current parks are modest in size and scope. Some, like the parks in North Carolina's research triangle, are huge. The research park at the University of Arizona, established in 1994, has full occupancy of 1.8 million sq. ft., and is now adding 600,000 sq. ft.

Linking the University to the Economy: Rensselaer Polytechnic Institute

Rensselaer Incubator Program was founded in 1980 as the first wholly university-based incubator in the nation. The Incubator Program provides a unique entrepreneurial environment - harnessing academic, research, and community resources to assist fledgling technology start-up enterprises.

George Low, Rensselaer's President when the incubator was conceived, said "The educational process of an institution like RPI depends upon the 'laboratory environment' that can only be found in growing, high technology companies. This type of laboratory cannot be duplicated in an exclusively academic situation. Newly spawned companies depend upon innovative ideas, and advice and counsel in science, engineering and management; they depend also on a continuing infusion of new people. Both the ideas and the people come from universities. Finally, RPI's actions will help stimulate the economic growth of the region and the state by attracting, nurturing and keeping high technology companies."

Since its inception, the Incubator Program's mission has been "giving life to new ideas". It is rooted in the firm belief that ideas both come from the University and are drawn to it. It is the Incubator's goal to augment the University's special role of providing a fertile environment for the growth and development of new ideas, and additionally to create opportunities for the application and further evolution of those ideas into the greater community through the channels of commercial activity. This greater mission encompasses three core objectives: Enrichment of the Academic Environment; Technology Transfer and Commercialization; and Regional Economic Development .

Surprisingly, there are few studies of the economic impact of research universities. The best is perhaps the 1997 BankBoston study of the Massachusetts Institute of Technology, "MIT: The Impact of Innovation." The 4000 companies founded by MIT graduates—including Hewlett-Packard, Rockwell International, Raytheon, McDonnell Douglas, Digital Equipment, Texas Instruments, Intel, Gillette, and even Campbell Soup—have annual sales equivalent to the 24th largest national economy in the world. The study makes it clear that MIT's hand's-on approaches to education—encouraging solutions to real-world problems brought in by faculty who engage beyond the university—instills unparalleled entrepreneurial spirit and state-of-the-art skills in MIT graduates.

Linking URI Research to RI's Economy

Starting Points. URI's natural advantages can be turned to address RI's need for technology-based industry.

- Having nearly 1 in 10 URI faculty in the biological sciences emphasizes the need for centralized facilities for **environmental biotechnology**.
- The Graduate School of Oceanography's research strength warrants investments in **ocean technology**.
- Facets of grant-competitive engineering research programs may provide kernels about which future URI engineering research centers can form.

Priority-setting. The State and the University need to work together to set priorities for investments such as the Environmental Biotechnology Initiative (i.e., centers that require major infrastructure and program development commitments). Both must seek consensus on an optimal investment plan for the state economy, based on investment in URI's R&D potentials.

The University must work closely with the State to meet State economic needs. State leaders must recognize that plans for shaping URI's research capacity will have to fit in with the institution's future aspirations and vision of itself. The University must recognize the reality and legitimacy of federal and state insistence that major public investments must eventually return public goods as outcomes.

Any strategy for targeting research investment must include both significant educational return and significant outreach (i.e., active engagement with target audiences who will benefit from research, advanced education, or technical collaboration). Clear educational or outreach missions are an unmistakable characteristic of every successful research center.

Entrepreneurial Culture for Learning. In its academic and research endeavors in science, engineering, and business, URI could develop a new culture for learning. Economically-focused research centers of excellence could balance curiosity-driven research of individual scholars. Greater engagement with business and technology leaders outside of the University, made possible through research collaboration and technical exchanges, could create feedback on the preparation of URI graduates—and their value to the economy as inventors, high technology employees, or entrepreneurs—and active pursuit of feedback is the hallmark of an institution concerned with the quality of its product. University science, engineering, and business departments could be better able to adjust the technical components of their curricula and enhance hands-on experiential learning through involvement in on-campus research centers and near-campus research / technology partnerships, thereby keeping on the leading edge.

Rhode Island needs to support its public research University in improving the state of URI research. Together, State and URI leaders must anticipate future State economic needs and URI's role in meeting them. At the very least, everyone concerned with URI's future should be mindful of the relative state of our commitments to higher education and to economically targeted research investment and of our clear need to do better.