

## DOCUMENT RESUME

ED 469 023

HE 035 279

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TITLE Condition of Research at Virginia Colleges & Universities. A SCHEV Report.  
INSTITUTION Virginia State Council of Higher Education, Richmond.  
PUB DATE 2002-05-22  
NOTE 49p.  
AVAILABLE FROM For full text: <http://www.schev.edu/Reportstats/ResearchReport052202.pdf>.  
PUB TYPE Reports - Evaluative (142)  
EDRS PRICE EDRS Price MF01/PC02 Plus Postage.  
DESCRIPTORS Facilities; \*Federal Aid; \*Financial Support; Higher Education; Public Policy; Research Universities; \*Research and Development; \*State Programs  
IDENTIFIERS \*Virginia

## ABSTRACT

To help facilitate focused and deliberate action, this report contains a current baseline assessment of the condition of research at colleges and universities in Virginia. The report brings together key sets of national data on research into one convenient place. It also provide a collection of many of the primary indicators used to assess how well individual institutions and states are performing in the competitive world of research. Data from various sources show that Virginia ranked 16th nationally in 2000 based on total academic research and development (R&D) expenditures. Findings show that the ability of research universities to attract federal support for R&D activities is driven largely by their ability to align faculty expertise with the federal research agenda. Virginia institutions appear to lag behind the top national research universities in terms of world-renowned researchers, and few of the state's science and engineering facilities are ranked among the top in the United States. The state's institutions of higher education experience a shortfall in the amount of space available to support their existing research programs, and the ability to conduct state-of-the-art research and its ability to attract world-class faculty is dependent in part on the availability and sophistication of its research equipment, an ability that is compromised by budget reductions. Virginia's faculty members are not generating as much research support as their peers nationally. It is also apparent that the lack of state policies that support and foster academic research has hindered the ability of Virginia's institutions to advance their research efforts. Findings also show that most successful state R&D initiatives share key similar characteristics of focused areas of research, long term and sustained R&D investment, and collaborative efforts among higher education, government, and business and industry. (Contains 8 tables, 4 figures, and 42 references.) (SLD)

# A SCHEV REPORT

ED 469 023

## Condition of Research at Virginia Colleges & Universities

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STATE COUNCIL OF HIGHER EDUCATION FOR VIRGINIA  
ADVANCING VIRGINIA THROUGH HIGHER EDUCATION

## TABLE OF CONTENTS

INTRODUCTION AND SUMMARY .....	1
Key Findings .....	4
BENEFITS OF RESEARCH .....	6
VIRGINIA’S R&D ENTERPRISE .....	7
HIGHER EDUCATION RESEARCH IN VIRGINIA.....	9
VIRGINIA’S RESEARCH UNIVERSITIES .....	13
COMPETING WITH THE NATION’S TOP RESEARCH UNIVERSITIES ....	16
Element 1 – Expertise in Priority Areas .....	17
Element 2 – Human Capital.....	21
Element 3 – Physical Capital .....	25
Element 4 – Productive Programs.....	28
Element 5 – Conducive Policy Environment .....	32
COMPETING WITH THE NATION’S TOP RESEARCH STATES.....	35
Research Initiatives in Other States .....	35
Planning Efforts in Other States .....	39
Recent Efforts in Virginia .....	40
ADVANCING HIGHER EDUCATION RESEARCH IN VIRGINIA.....	41

## INTRODUCTION AND SUMMARY

One of the most resonant and recurring themes emerging from the ongoing work of the State Council of Higher Education for Virginia (SCHEV) to develop its *2003 Systemwide Strategic Plan for Virginia Higher Education* is the need to enhance the Commonwealth's leadership position in the new 21<sup>st</sup> century economy by increasing the level of research and development at Virginia's colleges and universities. This theme has resounded in conversations SCHEV has initiated with business and industry leaders as well as college and university presidents, faculty, and administrators. State leaders, notably Governor Mark R. Warner and leadership of the General Assembly, also have expressed great interest in this issue and their desire to move Virginia forward by strengthening the state's academic research capabilities.

To help facilitate focused and deliberate action, SCHEV provides in this report a current baseline assessment on the *Condition of Research at Virginia's Colleges and Universities* against which future progress can be measured. This report brings together key sets of national data on research into one, convenient place. It also provides a collection of many of the primary indicators used to assess how well individual institutions and states are performing in the competitive world of research. Taken in isolation, it often is difficult for many to see and understand fully the meaning of some of the individual indicators highlighted in this report. When considered together, however, these indicators provide a clearer picture that points out the magnitude of the challenges facing the Commonwealth in the area of research. This report also outlines some of the opportunities for further advancement in research that will require the Commonwealth's active attention and purposeful resolve to address.

This report includes a tremendous amount of information, facts and figures. It also provides timely examples of just some of the many positive impacts of research by Virginia colleges and universities. Yet, the report also has limitations.

SCHEV's primary purpose in releasing this report is three-fold: 1) to outline past policies and identify prominent issues; 2) to raise questions about the current status of academic research in Virginia; and 3) to document eight key findings that ought to factor into the planning and implementation of future activities undertaken by the Commonwealth. This publication is not intended to provide solutions, or even recommendations. Rather, such recommendations, strategies, and action plans are expected to emerge during the course of SCHEV's development of its *2003 Systemwide Strategic Plan for Virginia Higher Education* and the Governor's Higher Education Summit. Such recommendations and strategies will culminate in an action plan for research at Virginia's colleges and universities by the end of this year.

True to the coordinating role that lies at the heart of its mission, SCHEV is redoubling its commitment to engage and work collaboratively with state policymakers, the higher education community, industry and business leaders, federal government officials, and other key research stakeholders. By forging a shared vision for academic research, articulating specific goals, crafting concrete strategies to achieve them, and working to maintain the Commonwealth's commitment to this important issue over the long-term, we believe Virginia has much to gain. By making research a priority, the Commonwealth and its citizens stand to benefit from expanding knowledge, stronger economic growth, a sharper competitive edge, more high-wage, high-tech jobs, and a better quality of life.

Of course, Virginia's colleges and universities for decades have played a critical role in advancing research in the Commonwealth. They have had many successes. Yet, Virginia higher education faces significant challenges in garnering the appropriate human, physical, and financial resources needed to support world-class research. In recent years, Virginia's colleges and universities have operated in an environment that has not always supported research. Whether implicitly or explicitly, many state higher education policies have sent a message to Virginia's colleges and universities: An institution's research mission is secondary to its instructional mission; undergraduate students are a priority over graduate students; and investments that produce immediate returns and are low-risk are preferable to longer-term, potentially more risky ventures. Even in this environment, Virginia institutions have done surprisingly well in gaining national recognition for their individual efforts in research. Their success to date provides a strong foundation upon which Virginia can, and must, build its research capabilities if it is to remain competitive in the future.

### **Virginia's R&D Enterprise**

Stretching across business and industry, federal government agencies and laboratories, and colleges and universities, Virginia's research and development (R&D) activities currently are a \$5 billion a year enterprise. In 1998, the last year for which data were available for all sectors, Virginia spent \$4.9 billion on R&D efforts, and this figure has continued to rise.<sup>1</sup> Industrial R&D accounts for over half of all research and development in the Commonwealth. Virginia's R&D expenditures in this area ranked the state 16<sup>th</sup> nationally in 1998. Research at federal government agencies accounts for another 30 percent of R&D expenditures in the state. Not surprisingly, given Virginia's close proximity to Washington, D.C. and the strong military and federal government presence in the state, Virginia ranked 4<sup>th</sup> nationally in terms of research activity in this sector. Only California, Maryland and the District of Columbia rank higher. By comparison, higher education accounts for a relatively small share of research in Virginia – accounting for approximately 10 percent of total R&D expenditures in 1998.<sup>2</sup>

## Higher Education Research in Virginia

Although academic research accounts for a relatively small share of the research conducted in the Commonwealth, the contribution of higher education in this area should not be understated. Whereas much of the research conducted by the federal government and industry is based on applied research or development, academic research tends to focus more on basic research, which forms the cornerstone of future knowledge and ultimately leads to new applications and development.

In looking only at academic R&D, Virginia ranked 16<sup>th</sup> nationally in 2000 based on total R&D expenditures. This ranking has been fairly consistent over the last 10 years. The competition for funding of academic research, however, is increasingly fierce. In 2000, the top four states accounted for 33 percent of the total academic R&D expenditures nationwide. The top 15 states accounted for almost 70 percent of the total expenditures. The facts provide a mixed message on the Commonwealth's research activity.<sup>3</sup> Although Virginia ranks among the top third of states in this area, much of the research activity is occurring in the higher ranked states. Furthermore, adjusting for the state's size and economic productivity, Virginia does not fare well at all. Looking at academic R&D expenditures per capita, Virginia ranked 37<sup>th</sup> nationally in 2000. Comparing academic R&D expenditures as a percentage of gross state product, Virginia drops even further – ranking 39<sup>th</sup> in that same year.

## Virginia's Research Universities

Turning from aggregate state-level expenditures and rankings to individual institutions' expenditures and rankings, a similar picture emerges. Based on total R&D expenditures at doctoral-granting institutions, none of Virginia's public or private colleges and universities currently ranks in the top 50 nationally. Virginia Tech and the University of Virginia fall just short – ranking 51<sup>st</sup> and 58<sup>th</sup> respectively in 2000. No other Virginia institution is ranked among the top 100 institutions.<sup>4</sup>

Although the rankings in and of themselves do not necessarily indicate the success of an institution's research program, they do allow for important comparisons. In looking at the expenditures of those top-tier institutions, it is clear that the most prominent research institutions account for the lion-share of the R&D activity in the nation. Of the 589 institutions tracked by the National Science Foundation, the top 40 accounted for over 50 percent of total academic R&D expenditures nationwide in 2000.<sup>5</sup> If Virginia's institutions want to improve their rankings, significant investments – from both the public and private sectors -- will need to be made.

## Competing with the Nation's Top Research Universities

If Virginia seeks to advance its research agenda, it will need to establish goals and develop strategies that promote a more conducive environment for research. Likewise, it



will need to invest its resources strategically – monetary, human, and physical – into strengthening the quality, effectiveness, and productivity of academic research programs. Through a review of the current literature and data, and through conversations with leading academics and researchers in the Commonwealth, SCHEV has identified eight key findings as to the condition of academic research in the Commonwealth.

## **8 Key Findings**

**Finding 1:** The ability of research universities to attract federal support for R&D activities is driven largely by their ability to align faculty expertise with the federal research agenda.

**Finding 2:** Despite the Commonwealth's efforts to attract and retain top-notch faculty, Virginia institutions still appear to lag behind the top national research universities in terms of world-renowned researchers.

**Finding 3:** Although many of Virginia's graduate research programs are nationally recognized, few science and engineering programs are ranked among the top-tier programs in the country. Without top-notch programs, Virginia will face increasing difficulty in attracting and developing world-class researchers in these, and related, fields.

**Finding 4:** Virginia's colleges and universities face a serious shortfall in the amount of research space available to support their *existing* research programs. Although the projects contained in the 2002 GOB referendum, if approved by voters, will help address this issue, Virginia's research universities will still face a research space deficit between 325,000 and 350,000 assignable square feet.

**Finding 5:** Virginia's ability to conduct state-of-the art research and its ability to attract world-class faculty is dependent, in part, on the availability and sophistication of its research equipment. For 15 years, the Higher Education Equipment Trust Fund (HEETF) has provided a predictable stream of funding to address this and other institutional technology issues. With budget reductions for the HEETF program now a reality, Virginia's institutions will lose ground.

**Finding 6:** Virginia's faculty are not generating as much research support as their peers nationally, based on research expenditures per full-time faculty.

**Finding 7:** The lack of state policies that support and foster academic research has hindered the ability of Virginia institutions to advance their research efforts. In support of undergraduate education, the Commonwealth has adopted numerous policies over the last decade that have intentionally or unintentionally placed a higher priority on teaching and learning as opposed to research. Those policies impacting Virginia's colleges and university research activities include:

- increasing faculty-teaching loads, resulting in less dedicated time for research;

- providing greater access to undergraduate education through tuition restraints and increased undergraduate financial aid, while graduate tuition rates escalate and state support for graduate financial aid stagnates. This focus appears to have limited opportunities for the Commonwealth to have invested in graduate education;<sup>1</sup>
- increasing administrative efficiencies through restructuring and decentralization efforts, inhibiting long-term investments, which has inhibited long-term investments in research;
- identifying adequate funding for instruction and academic support through the creation of a base adequacy funding formula that stops short of addressing funding needs for research, but which does not address institutions' research needs or funding for medical education or research needs for libraries;
- investing in the new construction and renovation of academic space and instructional technology, with only minimal investments in research facilities; and
- ensuring that institutions maximize the use of non-state resources to support the administrative functions associated with research, leaving institutions with less resources to re-invest in research activities.

**Finding 8:** Most successful state R&D initiatives share key similar characteristics: 1) focused area(s) of research; 2) long-term and sustained investments in research activities; and 3) collaborative efforts among higher education, government, and business and industry.

In many instances, these findings are inter-related. A lack of support in one area may impact the effectiveness of another. To advance academic research in Virginia, the Commonwealth will need to address these findings in a coordinated, strategic manner.

### **Advancing Higher Education Research in Virginia**

Virginia's academic research has thrived despite these obstacles. Future progress, however, will require a clearer vision about the goals for academic research and the investments needed to support that vision. Otherwise, individual Virginia colleges and universities may continue to thrive in their research efforts, but Virginia higher education as a whole may miss opportunities to advance not only academic research, but also the Commonwealth's economic development and the quality of life for its citizens. SCHEV pledges its full support to help increase the level of R&D at Virginia's colleges and universities through its creation of the *2003 Systemwide Strategic Plan for Virginia Higher Education*, to be completed in time for the 2003 General Assembly Session.

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<sup>1</sup> State support for graduate financial aid has remained virtually stagnant over the last decade.



## **BENEFITS OF RESEARCH**

As it enters the 21<sup>st</sup> century, Virginia's economic vitality hinges, in many ways, on its ability to further capitalize on the growing need for research and development (R&D). Since the end of World War II, university research has expanded the base of knowledge, dramatically improved Americans' quality of life, and helped make the U.S. an economic superpower. Indeed, research accomplished at institutions of higher education has touched the lives of almost every American.

In particular, university research has promoted better health and saved lives. These advances came through the creation of new vaccines, drugs, procedures and medical equipment. Since the early 1900s, inventions such as the electrocardiogram, defibrillator, contact lenses, and countless others have improved people's lives. In fact, the average person lives almost 30 years longer today than he or she did at the beginning of the 20<sup>th</sup> century, according to the National Academy of Engineers.<sup>6</sup>

Academic research also has contributed to advances in agriculture and improved the environment. This progress has come through the creation of cleaner energy sources, and new ways to reduce or eliminate pollution as well as produce and sustain crops more effectively. Researchers also have made discoveries that laid the foundation for many successful industries, including aeronautics, electronic components, plastics and new materials, computers and software and telecommunications hardware and services to name only a few.

Scientific inventions permeate our everyday-lives. In the last century alone, scientists have invented the vacuum cleaner, the dishwasher, the microwave oven, cellophane, nylon, and Teflon. More recently, university research paved the way for the development of the Internet, cellular telephones, and high-definition television.

Overall, these and other useful inventions have dramatically improved the quality of life for people living in the United States. Better still, the cutting-edge enterprises responsible for developing these inventions have created millions of jobs and contributed billions per year to our national economy. In fact, since 1995, the U.S. economy has increased 80 percent, according to the United States Office of Management and Budget (OMB). OMB estimates that the information technology field alone has accounted for about two-thirds of the nation's total economic growth since the mid-1990s.<sup>7</sup>

## **IMPACTING LIVES**

### **Selected Scientific Advances at Virginia's Institutions**

**Adenocard** – The late Dr. Robert M. Berne at the University of Virginia developed a drug to treat cardiac arrhythmia, using the naturally occurring chemical adenosine as his model. Today, his patented Adenocard is a staple in ambulances and paramedic kits.

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**Intel microprocessor technology** – Today, every Intel processor is powered by multiphase voltage regulator modules (VRMs), a device developed by the researchers at the Center for Power Electronics Systems (CPES) of Virginia Tech.

**In Vitro Fertilization (IVF)** – Teamed with researchers at Eastern Virginia Medical School, Dr. James R. Swanson at Old Dominion University co-invented IVF, a method to help women in assisted reproduction. He was the co-founder of the Jones Institute for Reproductive Medicine that conducted the first successful IVF in the United States.

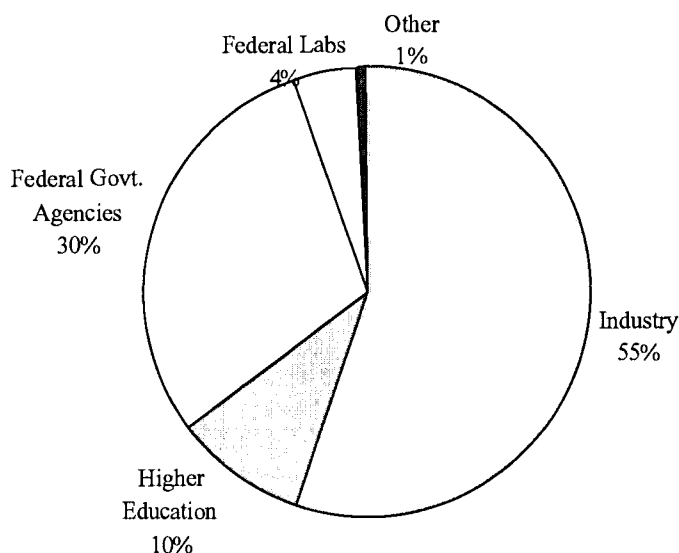
*Source: Examples provided by the sponsoring institutions.*

## VIRGINIA'S R&D ENTERPRISE

In Virginia, our higher education system is in the national forefront for its educational excellence and the quality of its academic programs. Over the last decade, however, research often has taken a back seat to teaching and learning in the public discourse surrounding Virginia's higher education system. While a few individual Virginia institutions are well-known for their research abilities, Virginia higher education collectively is not renowned for its accomplishments in this area – despite the fact that research is a huge enterprise in the Commonwealth.

The federal government, higher education institutions, and private businesses spent a combined \$4.9 billion in Virginia for research and development in 1998 – the last year for which data are available from all sectors. Based on these research expenditures, Virginia ranked in the top quartile nationally in terms of total R&D expenditures, placing it 12<sup>th</sup> in 1998. Over the last 15 years, Virginia's ranking has remained relatively stable, ranging between 12<sup>th</sup> and 14<sup>th</sup> among the 50 states and Washington, D.C.<sup>8</sup>

**Figure 1. Virginia's R&D Expenditures, by Sector  
Fiscal Year 1998**

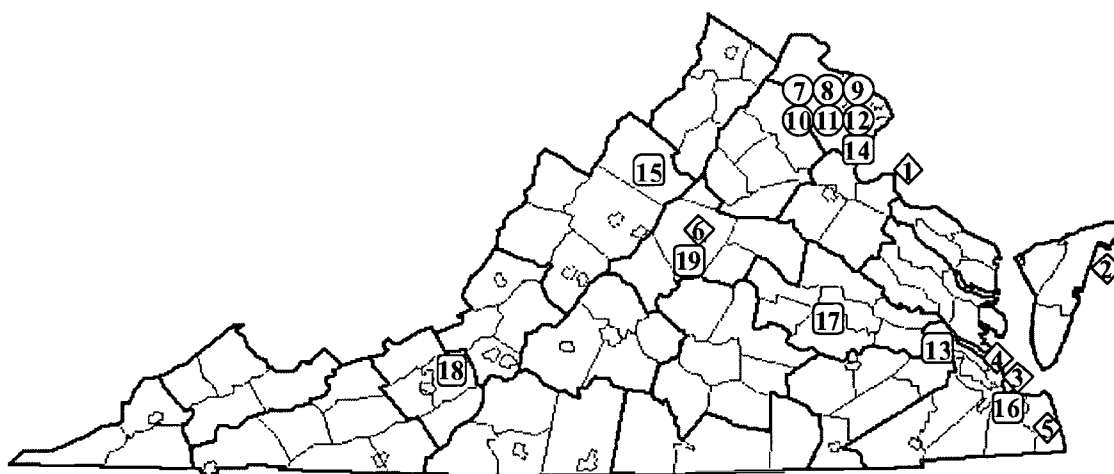


Source: National Science Foundation, *Science and Engineering Indicators* – 2000.

Virginia's relatively high national rankings have been driven largely by industrial R&D, which accounts for 55 percent of the research activity in the state, as shown in Figure 1. In fact, Virginia ranked 16<sup>th</sup> nationally among the 50 states and the District of Columbia in terms of R&D expenditures by industry in 1998.<sup>9</sup>

R&D expenditures at federal government agencies accounted for almost one-third of Virginia's research activity in 1998. Virginia ranked among the top states for research expenditures in this area – ranking 4th in that same year. Only Maryland, Washington, D.C., and California ranked higher.<sup>10</sup> Virginia has ranked consistently in the top states for federal research activity, due in large part to its close proximity to Washington, D.C. and its relatively high density of federal agencies, including NASA Langley Research Center, the Defense Advanced Research Projects Agency (DARPA), and others.

**Figure 2. Top Research Facilities in the Commonwealth**



**Federal Laboratories,  
Agencies, and Centers**

1. Dahlgren, Naval Surface Warfare Center
2. NASA Wallops Space Flight Center
3. NASA Langley Research Center
4. Thomas Jefferson National Laboratories
5. Joint Training and Simulations Center
6. National Ground Intelligence Center
7. National Reconnaissance Center
8. Office of Naval Research
9. Air Force Office of Scientific Research
10. Army Research Office
11. DARPA
12. National Science Education

**Virginia's  
Research Universities**

13. College of William and Mary
14. George Mason University
15. James Madison University
16. Old Dominion University
17. Virginia Commonwealth University
18. Virginia Tech
19. University of Virginia

Source: Chmura Economics and Analytics,  
*Identifying High-Tech Growth Opportunities in  
Virginia*, October 2000.

In total, business, industry and federal agencies account for approximately 85 percent of the state's R&D activities. Higher education accounts for only about 10 percent of Virginia's research efforts, with most of the remaining research occurring at federally supported laboratories.<sup>11</sup>

**RECAP:**  
**VIRGINIA'S R&D ENTERPRISE**

- ✓ Virginia ranked in the top quartile of states nationally in terms of total R&D expenditures in 1998.
- ✓ Industrial R&D accounts for one-half (55%) of Virginia's total R&D enterprise, ranking the Commonwealth 16<sup>th</sup> nationally in 1998.
- ✓ Federal government agencies and federally supported research laboratories account for almost another one-third (30%) of Virginia's R&D activities. R&D expenditures by federal government agencies in Virginia ranked the Commonwealth 4<sup>th</sup> nationally in 1998.
- ✓ R&D expenditures at research universities accounted for approximately 10% of total state R&D expenditures in Virginia in 1998.

**HIGHER EDUCATION RESEARCH IN VIRGINIA**

Although Virginia's colleges and universities account for only about 10 percent of total R&D expenditures in the Commonwealth, their role in R&D is vital. Whereas most industrial R&D focuses on development and much of the federal government's research focuses on applied research, the vast majority of R&D expenditures in higher education are directed toward basic research, which provides the foundation upon which future applied research and development are based. The National Science Foundation estimates that basic research at colleges and universities accounts for almost one-half of all basic research expenditures in the country.<sup>12</sup>

Among the top 15 states with the highest total R&D expenditures nationally, higher education accounts for only about 11 percent, on average, of those expenditures. In 1998, academic R&D as a percentage of total R&D in those states ranged from a low of 4 percent in New Jersey to a high of 17 percent in Maryland.<sup>13</sup> Overall, Virginia's research universities placed the state 15<sup>th</sup> nationally in terms of the level of academic research expenditures in 1998.<sup>14</sup>

**Components of R&D**

**Basic Research** seeks to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.

**Applied Research** focuses on increasing knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

**Development** is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

*Source: National Science Foundation, Science and Engineering Indicators, 2000.*

In 2000, total R&D expenditures at Virginia's doctoral-granting institutions fell slightly from their 1998 levels, ranking the Commonwealth 16<sup>th</sup> among the 50 states and the District of Columbia. Table 1 provides a ranking of the top states for total R&D expenditures in 2000 among doctoral-granting colleges and universities. Over the past 15 years, Virginia has ranked consistently among the top 20 states in terms of academic R&D expenditures.<sup>15</sup>

**Table 1. Total R&D Expenditures  
at Doctoral-Granting Institutions  
*Top States in 2000***

<b>Rank</b>	<b>State</b>	<b>Expenditures in millions</b>	<b>Percent of US Total</b>
1	CA	\$3,959,884	13.4%
2	NY	2,240,471	7.6%
3	TX	2,004,127	6.8%
4	PA	1,538,031	5.2%
5	MD	1,495,132	5.1%
6	MA	1,469,070	5.0%
7	IL	1,157,321	3.9%
8	NC	1,014,712	3.4%
9	MI	986,941	3.3%
10	OH	913,839	3.1%
11	GA	913,704	3.1%
12	FL	842,398	2.9%
13	WI	652,605	2.2%
14	WA	634,138	2.1%
15	MO	609,304	2.1%
<b>16</b>	<b>VA</b>	<b>576,945</b>	<b>2.0%</b>
	<b>US Total</b>	<b>\$29,522,106</b>	<b>100.0%</b>

Source: National Science Foundation, *National Patterns of R&D Resources – 2000*.

The top four states in Table 1 – California, New York, Texas, and Pennsylvania – accounted for approximately 33 percent of the nation's academic R&D expenditures in 2000. The top 10 states accounted for about 56 percent of the total expenditures nationally, while the top 15 states accounted for almost 70 percent of the national total. Therefore, even though Virginia ranked 16<sup>th</sup> nationally in terms of total R&D expenditures in higher education, it accounted for only two percent of total national academic R&D expenditures that year.

To move into the top 15 ranked states, Virginia institutions would have needed to spend at least \$33 million – or 5 percent – more in 2000. To reach a top 10 ranking that year, Virginia institutions would have had to spend ten times more than that amount – at least an additional \$337 million in support or almost a 60 percent increase over actual 2000 expenditures. Incredibly, to reach a top 5 ranking, Virginia institutions would have needed to spend an additional \$900 million – or an increase of 160 percent over its 2000 academic R&D expenditures.<sup>16</sup>

It does not appear that Virginia is gaining much ground relative to many of the top research states. Throughout much of the last decade, growth in federal support for academic R&D in Virginia has increased at the same level as the average growth among the top 15 research states nationally. By comparison, growth among the other major supporters of academic R&D – state and local government, industry, and institutional support – has meant Virginia lagged behind other top states. If Virginia is going to increase its national rankings in this area, the state must grow faster, on average, than the other leading states. Average or below average growth will not improve Virginia's prominence in this area over the long run. Table 2 summarizes the change in funding for academic R&D for the top 15 states and Virginia between 1992 and 2000.

**Table 2. Growth in Academic R&D Funding, By Source  
1992 to 2000**

Rank	State	Federal Govt	State & Local Govt	Industry	Institutional Support	Other	Total
1	CA	48%	100%	212%	91%	113%	69%
2	NY	46%	32%	10%	98%	51%	50%
3	TX	77%	53%	53%	14%	36%	57%
4	PA	67%	97%	42%	28%	80%	59%
5	MD	31%	-1%	-1%	8%	215%	30%
6	MA	46%	178%	45%	37%	34%	46%
7	IL	71%	36%	25%	62%	24%	59%
8	NC	68%	59%	165%	123%	54%	84%
9	MI	62%	57%	46%	46%	10%	52%
10	OH	55%	66%	119%	119%	25%	67%
11	GA	59%	92%	119%	88%	155%	78%
12	FL	79%	222%	124%	102%	78%	99%
13	WI	45%	-32%	6%	220%	61%	56%
14	WA	48%	10%	114%	110%	55%	59%
15	MO	104%	45%	23%	87%	98%	90%
<b>Average, Top 15</b>		<b>60%</b>	<b>68%</b>	<b>74%</b>	<b>82%</b>	<b>73%</b>	<b>64%</b>
<b>16</b>	<b>VA</b>	<b>60%</b>	<b>40%</b>	<b>55%</b>	<b>67%</b>	<b>56%</b>	<b>58%</b>

Source: National Science Foundation, *National Patterns of R&D Resources – 2000*.

Further, Virginia does not compare favorably to other states when total R&D expenditures are evaluated as a percentage of gross state product. Through this comparison, it is possible to see how states measure up after adjusting for differences related to their economic size. Looking at total R&D expenditures at doctoral-granting institutions of higher education as a percentage of gross state product, Virginia falls well below the national average – ranking 39<sup>th</sup> overall in 1999, the most recent year for which gross state product data are available.<sup>17</sup>



By comparison, states like Maryland, Massachusetts, and Utah tend to jump to the top of the list when gross state product is considered. Table 3 shows selected state rankings for total higher education R&D expenditures per gross state product in 1999.

**Table 3. Total R&D Expenditures  
at Doctoral-Granting Institutions per Gross State Product  
Top States in 1999**

Rank	State	Expenditures (in millions)	GSP (in millions)	Expenditures per GSP
1	MD	\$1,379,742	\$174,710	7.90
2	MA	1,380,737	262,564	5.26
3	UT	273,192	62,641	4.36
4	IA	370,651	85,243	4.35
5	NM	221,788	51,026	4.35
5	DC	218,044	55,832	3.91
6	MT	79,847	20,636	3.87
7	HI	156,810	40,914	3.83
8	NE	205,363	53,744	3.82
9	NC	980,612	258,592	3.79
10	VT	64,049	17,164	3.73
11	RI	120,868	32,546	3.71
12	ND	61,695	16,991	3.63
13	PA	1,389,395	382,980	3.63
14	AL	405,323	115,071	3.52
15	AK	88,825	26,353	3.37
	<b>US Avg</b>	<b>\$528,382</b>	<b>\$182,529</b>	<b>2.89</b>
<b>39</b>	<b>VA</b>	<b>523,335</b>	<b>242,221</b>	<b>2.16</b>

Source: National Science Foundation, *Academic Research and Development Expenditures, Fiscal Year 1999* and U.S. Bureau of Economic Analysis, *Gross State Product Data*, 2001.

An alternative way to adjust for variance among state size and productivity is to consider academic R&D expenditures relative to total population by state. The National Science Foundation also has ranked state academic expenditures on a per capita basis. Virginia's ranking for academic R&D expenditures per capita declined from 33<sup>rd</sup> in 1993 to 37<sup>th</sup> in 2000. In short, although Virginia seems to be holding its own in national comparisons of state total R&D expenditures, in terms of per capita spending and spending relative to gross state product, Virginia is not keeping pace with other top research states in the country.

## RECAP: HIGHER EDUCATION RESEARCH IN VIRGINIA

- ✓ Virginia has ranked consistently among the top 20 states over the last decade in terms of total R&D expenditures at colleges and universities.
- ✓ In 2000, Virginia ranked 16<sup>th</sup> nationally in terms of R&D expenditures at doctoral-granting institutions. Virginia ranked slightly higher – 15<sup>th</sup> – in 1998.
- ✓ Virginia's expenditures for academic research accounted for only 2% of total academic R&D expenditures in 2000. By comparison, academic R&D states at the top four states comprised 33% percent of the nation's total expenditures.
- ✓ Virginia does not fare well when R&D expenditures are adjusted for economic productivity or state size. Based on R&D expenditures per gross state product, Virginia's ranking dropped to 39<sup>th</sup> – placing it in the bottom quartile of the nation. Based on R&D expenditures per capita, Virginia's colleges and universities ranked 37<sup>th</sup> nationally in 2000.

## VIRGINIA'S RESEARCH UNIVERSITIES

Turning from higher education at a statewide level to an institutional level, the news for Virginia again is mixed. Based on total R&D expenditures at doctoral-granting institutions, none of Virginia's public or private colleges and universities currently ranks in the top 50 nationally. In 2000, Virginia Tech (VT) led the way among Virginia institutions, ranking 51<sup>st</sup> in total R&D spending. That year, VT spent almost \$193 million compared to the University of Virginia (UVA), which spent about \$175 million and ranked 58<sup>th</sup> nationally.<sup>18</sup> That same year, 11 other Virginia institutions also were included among the 589 institutions ranked by the National Science Foundation for total R&D expenditures. All 11 of these institutions, however, fell below the top 100 institutions. Collectively, they spent about the same amount as UVA on R&D in that year.

Nationwide, only a select group of higher education institutions accounts for the majority of R&D expenditures in the country. In 2000, the top 40 institutions or about 15 percent of research institutions tracked by the NSF accounted for just over 50 percent of the total R&D expenditures among higher education institutions across the country, according to data released by the National Science Foundation.<sup>19</sup>

### National Rankings for Virginia's Research Universities *Based on 2000 R&D Expenditures*

#### TOP 100:

Virginia Tech	51 <sup>st</sup>
University of Virginia	58 <sup>th</sup>

#### OTHER RANKED INSTITUTIONS:

Virginia Commonwealth Univ.	106 <sup>th</sup>
College of William and Mary	157 <sup>th</sup>
George Mason University	173 <sup>rd</sup>
Old Dominion University	180 <sup>th</sup>
Hampton University	244 <sup>th</sup>
Virginia State University	297 <sup>th</sup>
Norfolk State University	317 <sup>th</sup>
University of Richmond	416 <sup>th</sup>
James Madison University	420 <sup>th</sup>
Radford University	486 <sup>th</sup>
Virginia Military Institute	519 <sup>th</sup>

*Source: National Science Foundation, Academic Research and Development Expenditures – Fiscal Year 2000.*

Among those top 40 institutions, less than one-third are private institutions, suggesting that the majority of higher education research in the nation occurs at public colleges and universities. In Virginia, this trend certainly holds true. Only two private institutions in the Commonwealth – Hampton University and University of Richmond – are ranked nationally in terms of their total R&D expenditures.

### Top 40 Research Universities Based on 2000 R&D Expenditures

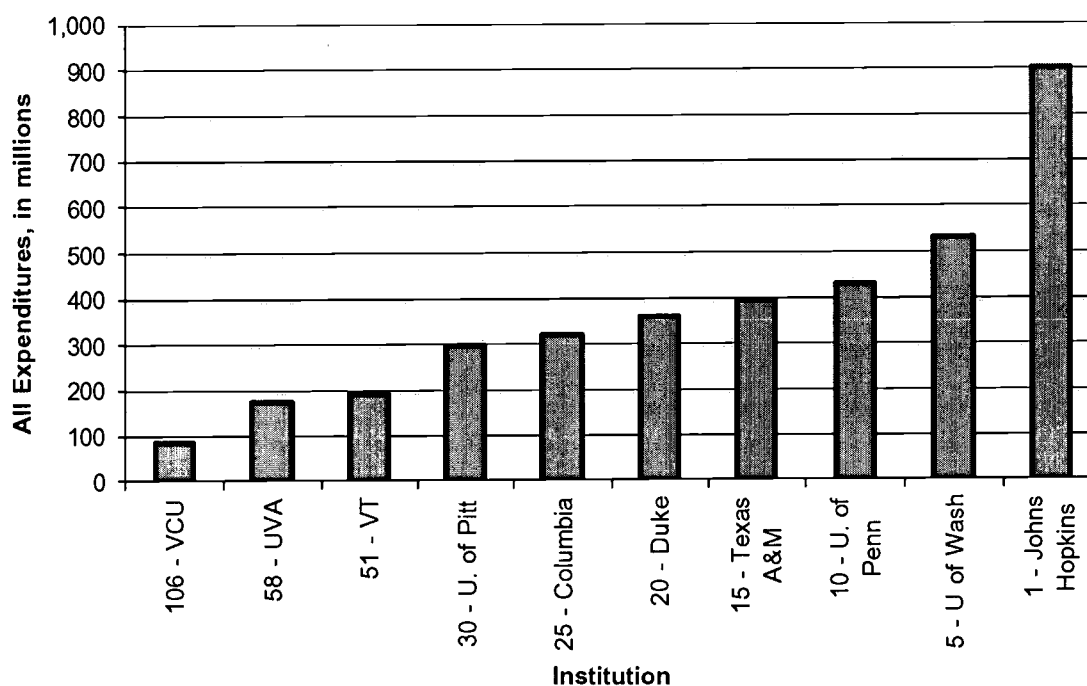
Institution	Affiliation	Institution	Affiliation
1 Johns Hopkins University	Private	21 University of Colorado	Public
2 University of Wisconsin – Madison	Public	22 University of Arizona	Public
3 University of Michigan	Public	23 Harvard University	Private
4 Univ. of California – Los Angeles	Public	24 Baylor College of Medicine	Private
5 University of Washington	Public	25 Columbia University	Private
6 Univ. of California – San Diego	Public	26 University of Florida	Public
7 Univ. of California – Berkeley	Public	27 Georgia Institute of Tech	Public
8 Stanford University	Private	28 Univ. of Southern California	Private
9 Univ. of California – San Francisco	Public	29 Yale University	Private
10 University of Pennsylvania	Private	30 University of Pittsburgh	Public
11 Pennsylvania State University	Public	31 NC State University	Public
12 Massachusetts Institute of Tech.	Private	32 Univ. of Texas – Austin	Public
13 University of Minnesota	Public	33 Univ. of NC – Chapel Hill	Public
14 Cornell University	Private/Public	34 University of Georgia	Public
15 Texas A& M University	Public	35 Univ. of MD – College Pk	Public
16 Univ. of Ill. Urbana-Champaign	Public	36 LA State Univ. System	Public
17 University of California – Davis	Public	37 Northwestern University	Private
18 Washington University	Private	38 University of Iowa	Public
19 Ohio State University	Public	39 Purdue University	Public
20 Duke University	Private	40 Univ. Ala. – Birmingham	Public

Source: National Science Foundation, *Academic Research and Development Expenditures – Fiscal Year 2000*.

Competition for external support of research projects is fierce among top ranked institutions, as evidenced in Figure 3. As institutions move further up the rankings, their share of the research grows dramatically. Based upon this trend analysis, in order for Virginia Tech (VT) to reach its stated goal of ranking in the top 30 nationally, it will need to increase its R&D expenditures over 50 percent. To move beyond that level, VT would

need to increase its research expenditures by 85 percent to be ranked among the top 20 institutions, over 100 percent to reach the top 15, almost 125 percent to reach the top 10, 175 percent to reach the top 5 and an astonishing 350 percent to complete with Johns Hopkins University – the top ranked research institution in the country.

**Figure 3. FY2000 R&D Expenditures  
at Top Research Universities**



Source: National Science Foundation, *Academic Research and Development Expenditures, Fiscal Year 2000*.

**RECAP:**  
**VIRGINIA'S RESEARCH UNIVERSITIES**

- ✓ None of Virginia's colleges or universities ranked among the top 50 research universities nationally in 2000 for total R&D expenditures. VT ranked 51<sup>st</sup> and UVA ranked 58<sup>th</sup>.
- ✓ R&D expenditures at the top 40 research institutions nationally account for over one-half of total R&D expenditures in higher education across the country.
- ✓ The competition among top research universities is fierce. In order to break into the top echelon of research institutions, Virginia's universities will have to increase their research activities by hundreds of million of dollars annually.

**COMPETING WITH THE NATION'S TOP RESEARCH UNIVERSITIES**

In order to compete with the nation's top research universities, Virginia's institutions must be able to attract, sustain, and enhance funding for academic R&D. Although academic research programs are most often evaluated based on the amount of funding they generate or their level of expenditures, successful R&D programs require at least five key elements:

- Element 1: Expertise in Priority Areas**
- Element 2: Human Capital**
- Element 3: Physical Capital**
- Element 4: Productive Programs**
- Element 5: Conducive Policy Environment**

Evaluating the strength of these elements, however, can be difficult, in part, because of their inter-relatedness. A weakness in any one area can create weaknesses in another. For example, if an institution has developed expertise in an area that is not a priority to major sponsors, it may be difficult to attract external support. An institution's ability to develop expertise in priority areas, however, cannot occur without an environment that supports and develops high quality researchers in that area. An institution's ability to attract world-class researchers may be limited if it does not have appropriate research facilities in which faculty can work. Faculty may not be productive if they do not have sufficient human resources -- including graduate research assistants -- sufficient space, equipment and technology, or a conducive environment in which to work. Despite the difficulty in assessing R&D efforts in the state, several indicators provide some insight into the strengths and weaknesses of the academic research enterprise in the Commonwealth.

## **VIRGINIA'S GROWING EXPERTISE IN PRIORITY RESEARCH AREAS**

According to the Virginia Research and Technology Advisory Commission (VRTAC), Virginia's colleges and universities are developing growing national expertise in the following areas:

### **★Bioinformatics and life sciences**

- Va. Commonwealth Univ.
- Virginia Tech
- George Mason University
- University of Virginia
- College of William & Mary

### **★Information security**

- James Madison University
- George Mason University
- Hampton University
- University of Virginia

### **★Nanotechnology**

- University of Virginia
- Va. Commonwealth Univ.
- College of William & Mary
- Virginia Tech

### **★Modeling and Simulation**

- Old Dominion University
- George Mason University
- University of Virginia
- Hampton University
- College of William & Mary

### **★Advanced Materials**

- University of Virginia
- Va. Commonwealth Univ.
- Virginia Tech
- James Madison University
- Old Dominion University
- Norfolk State University
- College of William and Mary
- Virginia State University

Source: VRTAC *Briefing to Virginia's Congressional Delegation*, 2002, and institutional reporting to SCHEV.

## **ELEMENT 1 – Expertise in Priority Areas**

Support from the federal government drives the majority of academic research in this country. Nationally, federal support for research is the top source of funding for higher education institutions. In 2000, funding from the federal government accounted for almost 60 percent of total research expenditures at colleges and universities. Support from private industry made up the second biggest share that year – about 20 percent of total funds for research. Support from state government, institutional funds, and other sources accounted for the remaining research expenditures in higher education.<sup>20</sup>

Not surprisingly, many of the institutions that rank high for total R&D expenditures also rank high in terms of federal research expenditures. In total, the top 30 institutions accounted for about 50 percent of all federal R&D expenditures among colleges and universities.<sup>21</sup>

In Virginia, UVA ranked 45<sup>th</sup> nationally in terms of federal R&D expenditures, spending \$119.2 million in 2000. VT ranked 77<sup>th</sup> with \$71.2 million and Virginia Commonwealth University (VCU) ranked 99<sup>th</sup> with \$52.1 million that year.<sup>22</sup>

Because federal funding for research is driven largely by relatively few federal agencies, institutions with expertise in related areas have a clear advantage in attracting federal research dollars. In fact, the federal Office of Management and Budget estimates that support from just three U.S. government agencies – the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense (DoD) – accounts for approximately 80 percent of total federal R&D funding.<sup>23</sup> Given the influence of these three agencies, institutions seeking to gain, or even simply maintain, federal support must be responsive to the research priorities of these agencies.



Over the next several years, NIH,<sup>24</sup> NSF,<sup>25</sup> and DoD<sup>26</sup> have identified among their priorities:

- Genomics and genetic medicine (NIH)
- Cancer research (NIH)
- Bioterrorism research (NIH, DoD)
- Proteomics (NIH)
- Biocomplexity in the Environment (NSF)
- Information Technology Research (NSF, DoD)
- Nanoscale Science & Engineering (NSF, DoD)

In 2001, research support from the NIH alone accounted for almost 60 percent, or \$10.7 billion, of all federal R&D funding.<sup>27</sup> In Virginia, NIH support accounts for about 50 percent of all funding for university R&D, according to the Virginia Research and Technology Advisory Commission.<sup>28</sup>

In light of the NIH's significant impact on the federal research agenda, it is not surprising that among the top 40 institutions for federal R&D expenditures, over 80 percent have medical schools.<sup>29</sup> In fact, 56 percent of total academic R&D expenditures were in the life sciences in 1997. Engineering accounted for the next largest research field that year, with approximately 16 percent of academic R&D expenditures.<sup>30</sup> Interestingly, among the 27 public institutions ranked among the top 40 nationally, 18 universities or 67 percent are land-grant institutions and almost 50 percent are land-grant institutions with medical schools.<sup>31</sup> Virginia has two institutions with land-grant missions – Virginia Tech and Virginia State University. The state has three medical schools – Eastern Virginia Medical School, the University of Virginia, and Virginia Commonwealth University.

Virginia's emerging expertise in the life sciences is clearly evidenced by recent investments in academic programs, facilities and research initiatives in related areas across several institutions. Through the recent creation of the Commonwealth Technology Fund (CTRF), Virginia also has identified several other priority areas, including:<sup>32</sup>

## **EMERGING RESEARCH IN VIRGINIA**

### **Improving National Security**

**Commonwealth Information Security Center (CISC)** -- created by the Commonwealth in July 2001, is located at James Madison University (JMU). It conducts applied research and technology transfer to increase the competitiveness of Virginia's information security industry and workforce as well as addressing the security needs of Virginia's IT industry and users. The center is a collaborative effort involving researchers at JMU, George Mason University (GMU), Hampton University, and Virginia Tech (VT), industry, and government.

### **Multifunctional Cellular Metals**

-- The Intelligent Processing of Materials Laboratory (Co-Directors: Professor H. Wadley and Dr. P. Parrish) at the University of Virginia is leading a major international research effort in extremely lightweight, multifunctional cellular metals. These materials are being developed to enable greatly improved thermal management in high power computing and spacecraft systems; to provide secure and blast resistant structures for aircraft, marine, and building applications, as a major component of the Nation's counter-terrorism strategy; and to provide multifunctional materials.

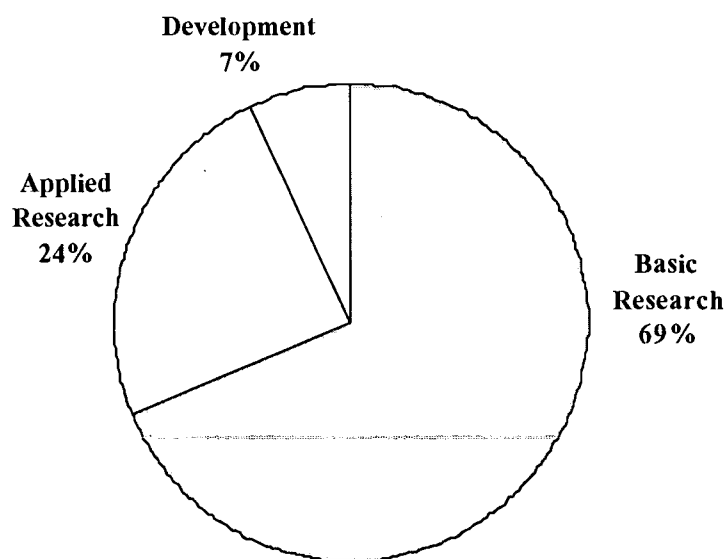
*Source:* Examples provided by the sponsoring institutions.

- Information technology and communications;
- Biotechnology and bioinformatics;
- Advanced materials and nanotechnology;
- Advanced manufacturing and biomanufacturing;
- Aerospace;
- Energy;
- Environmental technologies; and
- Transportation.

As Virginia seeks to increase external support for academic research in the state, the Commonwealth's commitment to, and support for, research in the life sciences and other national priority areas will become increasingly important.

Across all research fields, most federally supported R&D activities at institutions of higher education are directed to basic research while most industry-sponsored R&D supports applied research or development activities. Figure 3 identifies the proportion of federal funding dedicated to research versus development activities in 1999.

**Figure 3. R&D Activities at US Colleges and Universities**



Source: National Science Foundation, *Science & Engineering Indicators* – 2000.

Even with the federal government's continued and increasing support for research activities, its share of R&D expenditures is decreasing. In the mid-1960s, the federal government supported over 60 percent of all R&D activities in the nation – including those at research universities, federal government agencies, federal labs, and business and industry. By the early 1990s, the federal share had fallen below 50 percent and continued falling to less than 40 percent by the late 1990s. By comparison, the industrial share of research support has increased from roughly 30 percent in the mid-1960s to over 60 percent in the late 1990s.<sup>33</sup>

Despite the relative decline in federal support for research, it appears that federal funding will remain strong for the foreseeable future. Between 1996 and 2002, federal support for R&D increased 36 percent, following several years of minimal growth or decline. Adjusting for inflation, this change reflected a 22 percent increase during this same time.<sup>34</sup> Growth is expected to continue. During his presidential campaign, President Bush promised to double the NIH budget from its 1998 base appropriation and to increase funding for defense-related research. Congress is now considering the federal budget for FY2003, which includes the largest ever proposed federal R&D appropriation.

Looking specifically at Virginia's top-ranked research institutions, the level of federal funding varies significantly. In 2000, federal support for R&D activities at the University of Virginia (UVA) accounted for over 66 percent of the institution's R&D expenditures. At Virginia Commonwealth University (VCU), federal funds supported about 60 percent of all research expenditures that same year. At Virginia Tech (VT), federally supported research made up less than 40 percent of total R&D expenditures in 2000.

One potential reason for the variance in federal support among Virginia institutions is the presence of a medical school at both UVA and VCU. Given the significant level of funding provided to colleges and universities by the NIH, it is not surprising that VT ranks lower than its counterparts with medical schools. Among the nation's top research institutions, VT ranks in the top 10 among institutions without medical schools.

### **FINDING 1**

**The ability of research universities to attract federal support for their R&D activities is driven largely by their ability to align faculty expertise with the federal research agenda.**

## **EMERGING RESEARCH IN VIRGINIA**

### **Advances in Medicine**

#### **Treating Neurotrauma –**

Successful recovery from a traumatic head injury is often hampered by physiochemical events that obstruct normal brain activity. Dr. Ross Bullock and co-investigators at VCU are exploring new therapies that will rescue brain cells following a severe impact. They focus on protecting mitochondria, which produces energy for the brain to transmit signals, and evaluating the effectiveness of Cyclosporin A, a drug used as a therapeutic treatment for head injuries.

#### **Alzheimer's genes –**

Researchers at UVA were the first to link abnormalities in the function of Alzheimer's mitochondrial genes to one of the characteristic abnormalities found in the brains of patients with Alzheimer's disease in 1997. This research could be used to develop drugs to reverse the process or to prevent mitochondrial damage. The findings may shed light on new treatment for some cancers.

#### **Epilepsy Treatment –**

Dr. Robert DeLorenzo at VCU has found that the status epilepticus (SE), a life threatening seizure, is responsible for a higher rate of mortality than previously estimated. Based on his findings, new methods to estimate health risks have been developed and are being used by physicians to customize more effective patient treatment programs.

*Source:* Examples provided by the sponsoring institutions.

## **ELEMENT 2 – Human Capital**

A strong research program requires high caliber individuals – from leading research faculty to supporting researchers and graduate students. Virginia’s success in improving its human research capital will be determined by its ability to attract and retain top-notch faculty and develop future talent through its academic programs and research opportunities.

### ***Attracting and Retaining World-Class Faculty***

Although it is difficult to measure the quality of human capital at an institution of higher education, one potential indicator of the human capital at Virginia’s colleges and universities is the number of members of the National Academy of Science (NAS). The National Academy of Science elects members “in recognition of their distinguished and continuing achievements in original research. Election is considered to be one of the highest honors that can be accorded a scientist or engineer.”<sup>35</sup> In addition to the NAS membership, the Institute of Medicine (IOM) and the National Academy of Engineers (NAE) also identify leaders in their respective fields. Table 4 shows the number of NAS, IOM, and NAE members at each of the top 10 national research institutions based on total R&D expenditures in 2000, as well as the number of these members at VT, UVA, VCU, and GMU.

**Table 4. Memberships in the National Academies**

Rank	Public or Private Institution	Institution	NAS	NAE	IOM <sup>2</sup>
<b>Top 10 Research Universities<sup>1</sup></b>					
1	private	Johns Hopkins University	15	6	41
2	public	Univ. of Wisconsin - Madison	42	19	7
3	public	University of Michigan	22	17	25
4	public	UCLA	28	14	14
5	public	University of Washington	38	11	31
6	public	UC San Diego	60	13	21
7	public	UC Berkeley	119	71	9
8	private	Stanford University	112	83	44
9	public	UC San Francisco <sup>3</sup>	21	0	47
10	private	University of Pennsylvania	36	10	41
<b>Top 10 Average</b>			49	24	28
<b>Virginia Institutions</b>					
51	public	Virginia Tech <sup>3</sup>	3	9	0
58	public	University of Virginia	2	7	10
106	public	Va Commonwealth University	0	0	2
173	public	George Mason University <sup>3</sup>	2	0	0

<sup>1</sup> Based on total R&D expenditures in 2000.

<sup>2</sup> IOM members include those working in the hospital/health system.

<sup>3</sup> Institution does not have a Medical School.

Source: National Academies website directory, [www.nas.edu](http://www.nas.edu).

Looking at higher education, government agencies, and private industry combined, Virginia, as a state, has approximately 112 members of these academies – far fewer than most of the top research states. By comparison, California has 1,302 members of these academies. Most of the other top research states having hundreds of members: Illinois (175), Maryland (279), Massachusetts (681), New York (495), Pennsylvania (235), and Texas (232). In fact, among the top 10 research states, only North Carolina and Michigan come close to Virginia, with each of them having 123 National Academy Members statewide.

Virginia traditionally has maintained a long-term commitment to attracting and retaining faculty. In 1964, the state created the Eminent Scholars Program to attract and retain nationally renowned teaching and research faculty. As a public-private partnership, the program encourages private giving at Virginia's state-supported colleges and universities by providing state funds to match eligible endowment earnings. Institutions use the state match and the endowment earnings to supplement the salaries of their most outstanding faculty members. In 2001, SCHEV estimated that through the Eminent Scholars Program, Virginia's public institutions provided supplemental funding to over 500 faculty members across the state.

Although the program was originally designed to provide a dollar-for-dollar match on private earnings, state funding for the program has not kept pace over the last decade. As a result the state contributed only about 41 cents on the dollar for the program in 2001. Facing serious budget shortfalls for the next several fiscal years, state funding for the program will decrease eight percent by the end of the 2002-04 biennium, further eroding the level of state match.

In addition to the Eminent Scholars program, in the mid-1980s, the Commonwealth also established a policy of providing funding to ensure that average salaries among Virginia's teaching and research faculty are at the 60<sup>th</sup> percentile of their peers nationally. Lack of state support, however, has resulted in the state reaching the 60<sup>th</sup> percentile goal in only two biennia – 1988-1990 and 1998-2000. As with the Eminent Scholars program, the state's current fiscal situation will likely erode Virginia's progress in meeting the 60<sup>th</sup> percentile goal.

## **FINDING 2**

**Despite the Commonwealth's efforts to attract and retain top-notch faculty, Virginia institutions still appear to lag behind the top national research universities in terms of world-renowned researchers.**

## *Developing New Talent*

Attracting and retaining world-class research faculty, however often requires more than competitive salaries. Top researchers frequently command dedicated research space, specialized equipment, and graduate students who can provide research assistance. The ability to attract those students often depends on the quality of academic programs in key graduate fields and student financial aid packages. Compared to the top-ranked national research institutions, Virginia's research universities lag behind many of the leading best research universities.

**Table 5. Percent of Student Enrollments  
Classified as Graduate Students**

<b>Institution</b>	<b>% Graduate Students</b>
1 Johns Hopkins University	68%
2 University of Wisconsin -- Madison	21%
3 University of Michigan	34%
4 University of California -- Los Angeles	27%
5 University of Washington	23%
6 University of California -- San Diego	16%
7 University of California -- Berkeley	24%
8 Stanford University	52%
9 University of California -- San Francisco	57%
10 University of Pennsylvania	36%
<b>Average, Top 10 Institutions</b>	<b>36%</b>
<b>Virginia Institutions</b>	
51 Virginia Tech	22%
58 University of Virginia	32%
106 Virginia Commonwealth University	26%
<b>Average, Virginia Institutions</b>	<b>27%</b>

*Source:* Integrated Postsecondary Education Data System, 2000 Fall Enrollment Survey.

Evaluating the quality of graduate programs can be difficult. Although the National Research Council (NRC) – the prime operating agency of the National Academies of Science and Engineering – ranks graduate programs in science and engineering fields across the country, it only updates those rankings only once every 10 years. The NRC released its latest rankings in 1995. Those rankings were based on 1993 survey data. The NRC is in the process of updating its ranking methodology and will begin collecting information from institutions in the 2003-04 academic year. The next set of rankings will not be released until 2005.



Absent more recent data from the NRC, the most recent rankings from *U.S. News and World Report* may provide some insight into the strength and weaknesses of Virginia's graduate programs, particularly in the areas of science and technology. Table 6 summarizes those rankings in some key academic areas.

**Table 6. Nationally Ranked Science and Engineering Graduate Programs at Virginia's Colleges and Universities**

Nationally Ranked Graduate Programs	Virginia Ranking	
	Institution	Rank
<b>Biological Sciences</b>	UVA	36th
<b>Chemistry</b>	UVA	47th
Polymer chemistry program*	VT	5th
<b>Computer Science</b>	UVA	27th
	VT	42nd
<b>Engineering</b>	VT	23rd
	UVA	35th
<b>Engineering Specialities</b>		
Aerospace/Aeronautical Engineering	VT	17th
Bioengineering/Biomedical Engineering	UVA	15th
Chemical Engineering	VT	22nd
Civil Engineering	VT	11th
Computer Engineering	VT	19th
Electrical Engineering	VT	16th
Environmental/Environmental Health Engineering	VT	10th
Industrial/Manufacturing Engineering	VT	8th
Mechanical Engineering	VT	17th
Agricultural Engineering	None	
Materials Engineering	None	
Nuclear Engineering	None	
Petroleum Engineering	None	
<b>Geography</b>	None	
Sedimentology program*	VT	9th
<b>Medical Research**</b>	UVA	27th
<b>Veterinary Medicine</b>	VT	17th

Notes:

\* 2001 ranking.

\*\* UVA made ranking, but it had the least NIH funding compared to other top programs.

Source: US News and World Report, 2003 Graduate School Rankings, [www.usnews.com](http://www.usnews.com)

Virginia clearly has developed some highly rated programs in science and engineering fields. However, in many cases, the programs fall short of getting top marks. Virginia's ability to attract graduate students in these fields will be affected largely by how these programs compete with similar programs nationally.

### **FINDING 3**

Although many of Virginia's graduate research programs are nationally recognized, few science and engineering programs are rated among the top-tier programs in the country. Without top-notch programs, Virginia will face increasing difficulty in attracting and developing world-class researchers in these, and related, fields.

#### **ELEMENT 3 – Physical Capital**

In order to be successful, researchers, particularly in science and technology fields, require ample quality space, with state-of-the-art research equipment.

##### ***Research Space***

Despite the importance of research space, few national norms exist for determining how much space is needed to conduct world-class research. The lack of standards is due, in part, to the complexity of this element. The need for research space varies by scientific field, intensity of research, and number of researchers. Nationally, however, the NSF estimates that as many as 50 percent of colleges and universities nationwide need to increase their research space by at least 25 percent.<sup>36</sup>

In the mid-1990s, SCHEV established a space guideline for research, which recommends the amount of research space institutions need based on the type and amount of research they conduct and their graduate student enrollments. SCHEV's space guidelines state that institutions should have at least:

### **EMERGING RESEARCH IN VIRGINIA**

#### **Partnering with Business**

**INCOGEN** – Through the Commonwealth Technology Research Fund's industry inducement program, the College of William and Mary, in collaboration with the Virginia Bioinformatics Institute at Virginia Tech, has negotiated an agreement with the Institute for Computational Genomics (INCOGEN) to relocate from South Carolina to James City County. Through a collaborative arrangement, Virginia's institutions and INCOGEN will work together to develop: better models for the analysis of life sciences data; easy-to-use software to manage and mine huge databases across the Internet; and experimental, computational and theoretical aspects of cell biology. Virginia successfully competed against North Carolina, Ohio and Colorado for this project.

**VECTEC** – The Virginia Electronic Commerce Technology Consortium (VECTEC) is a non-profit consortium of public and private organizations that work together to assist Virginia's business and government communities in adapting quickly to the technologies that power electronic commerce. Hosted and supported by Christopher Newport University, other partners include Virginia's Center of Innovative Technology, Northrup Grumman Newport News and Bell Atlantic. The primary goal of this project is to develop a prototype of the regional information superhighway for small businesses and to establish methods and procedures whereby small businesses may best benefit (improve profits) from telecommunications technologies.

*Source:* Examples provided by the sponsoring institutions.

## FUNDING FROM THE PRIVATE SECTOR

Although federal support accounts for the majority of R&D funding at Virginia's institutions, private industry funds about 10% of academic R&D expenditures in the Commonwealth. Industrial support for R&D is particularly important, given the dramatic increase of private sector support for applied research and development. Virginia's top research institutions fare well nationally in terms of industrial support for research – with all three ranking in the top 100. In 2000, UVA ranked 32<sup>nd</sup>, VT ranked 41<sup>st</sup>, and VCU ranked 82<sup>nd</sup>.

Virginia institutions also have won recognition for their efforts to support private industry research and development. For example, Virginia Tech was recently named one of the top 12 most innovative institutions in the country, based on its success in attracting industry-sponsored research and identifying opportunities for technology transfer.

*Sources: National Science Foundation, National Patterns of R&D Resources, 2000; and Southern Growth Policies Board, Innovation U. – New University Roles in a Knowledge Economy, 2002.*

*800 assignable square feet per \$100,000 of research expenditures (in constant 1993 dollars) in the hard sciences<sup>2</sup>*

*plus*

*10 assignable square feet per full-time equivalent graduate student (excluding medical, dental and veterinary students).<sup>37</sup>*

Using this standard, SCHEV found that although Virginia's higher education institutions reported having over 1.7 million assignable square feet (asf) of research space (excluding space for medical, dental, and veterinary research) in 2000, they still need over 700,000 asf – or an additional 40 percent – to support adequately current research activities. The 2002 General Obligation Bond referendum for higher education, if passed, would provide the construction of approximately 350,000 asf of new research and related space, among other projects. SCHEV estimates that even with this additional space, Virginia institutions still will face a space deficit of roughly 325,000 to 350,000 asf based on 2000 research expenditures and graduate student enrollment. Additional space for Virginia's colleges and universities may be further justified based on anticipated research expenditures in 2001 and 2002, projected graduate student enrollments, and growth in medical research.

If approved by the voters, the 2002 General Obligation Bond referendum will also provide the Commonwealth's top three research universities with 200,000 asf of new medical and veterinary research space. VCU, VT, and UVA currently estimate that they have approximately 1.4 million asf of medical, dental and veterinary research space, so the proposed projects would increase the available space in these areas by almost 15 percent. Unlike other academic research space, SCHEV does not have an explicit guideline for assessing how much medical research space is appropriate, despite the fact that the majority of federal funding supports medically related research. Instead,

<sup>2</sup> These include: Agriculture and Natural Resources, Engineering, Computer Science, Biological Sciences, Applied Mathematics and Statistics, Physical Sciences, Architecture and Environmental Design, Fine and Applied Arts, Home Economics, Psychology, Communications and Health Professions

SCHEV recommends those projects on a case-by-case basis. Similarly, SCHEV does not typically make capital budget recommendations for affiliated higher education agencies, including the Virginia Institute of Marine Science and the extension agencies at Virginia Tech and Virginia State University. Those agencies support another 550,000 asf of research space, which are not covered by SCHEV's existing guidelines.

In addition to its quantity, the quality of academic research space is another important factor in assessing the physical capital of R&D in a state. Based on SCHEV's 2000 Facility Condition Report, the overall average facility condition index (FCI) for educational and general (E&G) buildings that contain at least 50 percent research space is 11 percent. The FCI indicates the proportion of building deficiencies relative to the total value of the building. Based on national industry standards, any facility with an FCI greater than 10 percent is considered to be in "poor" condition. Of the 108 facilities included in SCHEV's *2000 Facilities Condition Report* having at least 50 percent of their space assigned to research, 58 buildings have a "good" FCI rating, 29 buildings are in "fair" condition, with the remaining 21 buildings in "poor" condition.

The FCI, however, only estimates the functional condition of the building. Specifically, it identifies whether the building and its systems (e.g., heating and air-conditioning, plumbing, and electrical system) are in good working condition. It does not assess the quality of the building or how modern the facility is. For research facilities, in particular, a quality assessment is often as important as a functional assessment. Data are limited, however, because the Commonwealth does not routinely assess building quality.

#### **FINDING 4**

**Virginia's colleges and universities face a serious shortfall in the amount of research space available to support adequately their existing research programs. Although the projects contained in the 2002 General Obligation Bond referendum, if approved by voters, will help address this issue, Virginia's research universities will still face a research space deficit between 325,000 and 350,000 assignable square feet.**

## *Research Equipment*

Faced with a growing need to upgrade technology and address institutional needs for modern research equipment, the Commonwealth established the Higher Education Equipment Trust Fund (HEETF) in 1986. The program leverages state support for institutions to purchase state-of-the-art instructional and research equipment and technology. For the first several years of the program, HEETF allocations were aimed at addressing discipline-specific equipment deficiencies. After these initial allocations, the HEETF has focused almost entirely on replacement of existing obsolete equipment. To date, a total of \$484.1 million has been allocated for the program. As with the Eminent Scholars program, however, the state's current budget situation will require reductions to the program, at least in the short term. The impact of those reductions will be noticeable. Not only will it reduce the ability of institutions to upgrade existing equipment, it will hamper their ability to attract top researchers who often require specialized equipment and lab facilities. For many institutions, the HEETF can provide a fund source to help put together recruitment packages that include not only competitive salaries, but also equipment and other resources needed to conduct world-class research.

### **FINDING 5**

**Virginia's ability to conduct state-of-the-art research and its ability to attract world-class faculty is dependent, in part, on the availability and sophistication of its research equipment. Over the past 15 years, the Higher Education Equipment Trust Fund has provided a predictable stream of funding to address this and other technology issues at institutions. With planned budget reductions for the program soon to be a reality, Virginia's institutions will lose ground in this area.**

### **ELEMENT 4 – Productive Programs**

Even if all of the human, financial and physical resources are in place, successful R&D programs are ultimately those that produce results and continue to generate funding for additional research efforts. As with many of the other elements, program productivity can be difficult to measure. A few indicators, however, provide some insight as to the productivity of Virginia's R&D efforts.

### ***Tracking Patent Awards and Growth in Production***

After a decade of surpassing the national average for growth in total patent production, the rate of increase in the number of patent awards across all sectors in Virginia has lagged behind the average national increase, as shown in Table 7.

**Table 7. Number of Patents Awarded Over Time**

<b>Year</b>	<b>Virginia</b>	<b>US</b>
<b><i>Total Patents Awarded</i></b>		
1980	555	40,768
1990	831	52,976
2000	1,286	97,016
<b><i>Percent Change</i></b>		
1980 to 2000	132%	138%
1980 to 1990	50%	30%
1990 to 2000	55%	83%

*Source:* United States Patent and Trademark Office website ([www.uspto.gov](http://www.uspto.gov)). *Patent Counts by State, By Year, All Patents and All Types: January 1, 1977 – December 31, 2000, March 2001.*

Looking only at Virginia's top-ranked public colleges and universities, it appears that patent production has been relatively stable over the last few years. Between 1998 and 2000, VT and UVA averaged 26 and 24 patent awards, respectively, each year. For 1999 and 2000, VCU averaged 20 awards, based on data compiled by the Association of University Technology Managers.

By comparison, during that same time period, the United States issued, on average, just over 3,000 patents a year to the top 140 national research institutions. The University of California System alone holds approximately 10 percent of those patents (averaging 282 annually each of the last three years). Ten institutions or systems account for approximately one-third of all patents awarded nationally to the top 140 research institutions, as shown in Table 8 on the following page.



**Table 8. Top Patent Awards at Research Universities  
Average Annual Awards, 1998-2000**

<b>Institution/System</b>	<b>Avg. Annual Awards</b>
University of California System <sup>1</sup>	282
Mass. Institute of Technology	144
Johns Hopkins University	98
Stanford University	91
California Institute of Technology	83
University of Wisconsin	83
University of Michigan	65
Columbia University	63
University of Pennsylvania	63
Cornell University	62
<b>Virginia Institutions</b>	
Virginia Tech	26
University of Virginia	24
Virginia Commonwealth University <sup>2</sup>	20

<sup>1</sup> The University of California reports its awards for all institutions in the system.

<sup>2</sup> VCU only reported in 1999 and 2000. This figure reflects the university's two-year average.

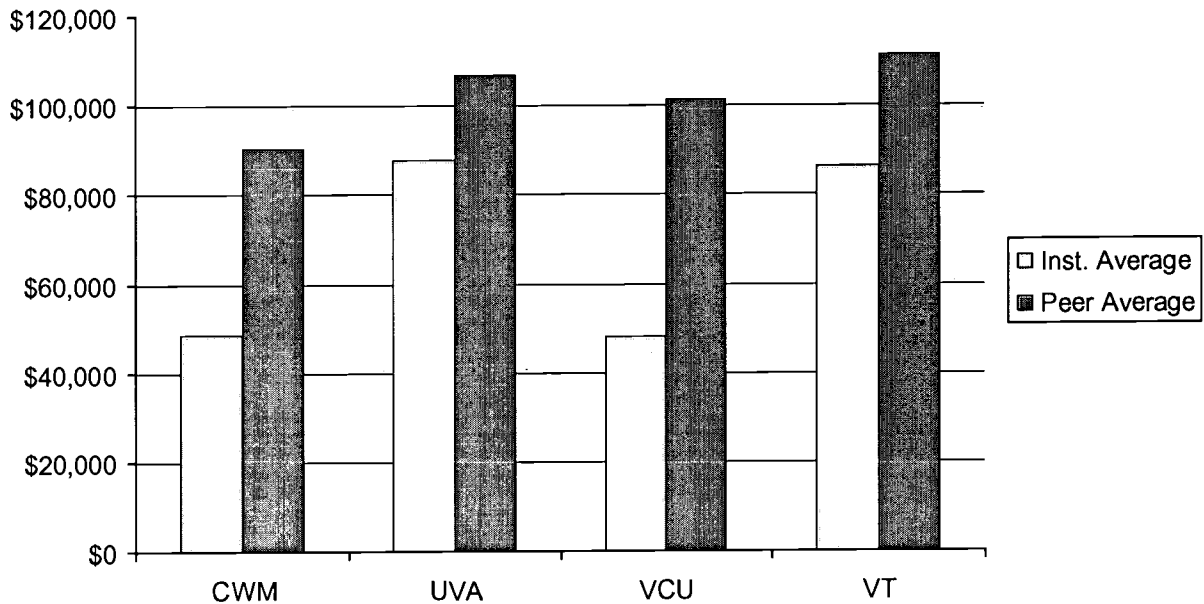
*Source: Chronicle of Higher Education, "Licensing Revenues and Patent Activity, Fiscal Year 2000," March 5, 2002.*

Despite the relatively low number of patents awarded in recent years, VT, UVA, and VCU indicate significant increases in the number of invention disclosures and licensing revenue. This positive development indicates the potential for future growth in this area.

### *Assessing Faculty Productivity*

While the number of eminent faculty can be used as one measure of human capital, it focuses only on a small proportion of the talented faculty pool at Virginia's institutions of higher education. Although it is difficult to assess the overall quality of researchers in the state, it is much easier to compare their overall activity level.

**Figure 4. 1999 R&D Expenditures Per Full-Time Faculty Member**



Source: State Council of Higher Education for Virginia, *2001 Reports of Institutional Effectiveness*, [www.schev.edu](http://www.schev.edu).

For several years, Virginia has tracked the level of research and public service expenditures per faculty member in an effort to assess one component of faculty productivity. Based on SCHEV's *2001 Reports of Institutional Effectiveness*, Virginia's public colleges and universities do not compare favorably to their national peers in this category. In fact, in 1999, UVA and VT generated only about four-fifths of the dollars per faculty as their peer institutions. Faculty at VCU and the College of William and Mary generated only about half as much as their peers nationally, as shown in Figure 4. Virginia's other major research institutions – George Mason University and Old Dominion University – did not report data for their peers in that year.

### **FINDING 6**

**Virginia's faculty are not generating as much research support as their peers nationally, based on research expenditures per full-time faculty.**

### **ELEMENT 5 – Conducive Policy Environment**

Through both their policies and funding decisions, states can create an environment that fosters and is conducive to R&D. In many cases over the past decade, a variety of policy and funding decisions have hindered the ability of Virginia's colleges and universities to expand their research capabilities. In fact, throughout much of the 1990s, the higher education policy debates in Virginia focused on:

- **increasing faculty-teaching loads:** Faced with concerns that Virginia institutions were relying too heavily on graduate assistants to teach undergraduate students, the Commonwealth has placed significant emphasis on putting faculty back in the classroom. While this policy clearly benefits undergraduate students in the short run, it may limit the discovery of new knowledge and the quality of instruction at the institutions in the long run. Without advances in research, not only will the research programs at Virginia's institutions suffer, but the undergraduate and graduate curricula will be diminished. Students benefit from instruction by cutting-edge researchers.
- **providing greater access to undergraduate education:** With increased funding for undergraduate programs, state-imposed limits on undergraduate tuition for in-state students, and increased financial aid, the Commonwealth has taken deliberate steps to ensure greater access to an undergraduate education. While these policies have clearly had a very positive impact, their focus appears to have limited opportunities for the Commonwealth to invest in graduate education. In particular, while graduate tuition rates have continued to rise for both in-state and out-of-state students, state support for graduate financial aid has remained stagnant since the early 1990s. Even through its own policies, SCHEV began in 1994 to explicitly require that institutions not divert funds from undergraduate programs to support graduate programs, even if the undergraduate program was obsolete or unproductive.
- **increasing administrative efficiencies, through restructuring and decentralization efforts:** For many institutions, restructuring efforts again resulted in directing limited resources to instruction and related activities. By its very nature, research requires long-term investments that do not always generate an immediate return on the investment. Research is risky business, and unless risks are rewarded, they may not be taken.
- **identifying adequate funding for instruction and academic support through the creation of a base adequacy funding formula:** The Joint Subcommittee Studying Higher Education Funding Policies has developed a funding model – endorsed by SCHEV via its 2002-04 budget recommendations – that aims to provide adequate base funding to institutions for instruction (both undergraduate and graduate), institutional support, academic support, student services, and operation and maintenance of plant.

The funding model, however, does not currently address research needs or funding for medical education or resources needs for libraries.<sup>3</sup>

- **investing in the new construction and renovation of academic space and instructional technology:** Although SCHEV's *Fixed Asset Guidelines* recommend that the state fund 50 percent of the cost of capital projects for research space through the general fund or through state-supported debt, the Commonwealth has made funding decisions on a project-by-project basis. As a result, the Commonwealth has made only minimal investments in research facilities over the last decade. These funds amount to roughly over \$25 million annually.
- **ensuring that institutions maximize the use of non-state resources to support the administrative functions associated with research:** By law, the Commonwealth requires that 30 percent of all indirect cost recoveries by colleges and universities from external research sponsors be reinvested in E&G (or instructional) programs to offset the administrative costs of the research programs.

Thus, the message, both implicitly and explicitly, has been that teaching and learning are a higher priority than research and discovery; undergraduate students are a priority over graduate students; and investments that produce immediate returns and are low-risk are preferable to longer-term, potentially more risky ventures. Too often, then, the choice has been framed or made as if Virginia can either excel at instruction or it can excel at research. While this either-or phenomenon could be explained in part by limited resources, rarely has the Commonwealth considered the benefit – indeed the synergy – of being national leaders in both. As a result, Virginia's colleges and universities appear to be losing their ability to compete with the nation's top research institutions.

The state's efforts to coordinate its policies in support of academic research have been limited. In 1984, after passage of the Bayh-Dole Act opened the market for technology transfer of federally-funded research, the Commonwealth established the Center for Innovative Technology (CIT) to enhance R&D and technology transfer efforts at Virginia's major research universities. By the mid-1990s, CIT focused more on the commercialization of technologies than on managing intellectual property, a function by this time largely handled by the universities themselves. The results of the stronger focus on economic development were measured by the number of jobs created and new companies formed, as well as the increases in the economic competitiveness of existing companies. Over the last several years, CIT has broadened its mission to:

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<sup>3</sup> Under the Appendix M funding guidelines used for higher education throughout the 1970s and 1980s, specific funding was provided for library resources. In addition, prior to the mid-1990s, the State Council of Higher Education for Virginia included space guidelines for library in its *Higher Education Fixed Asset Guidelines for Educational and General Programs*. Currently, both library materials and library space are funded on a case-by-case basis.

***enhance Virginia's business competitiveness through technology innovation.***<sup>38</sup>

As CIT's mission evolved, so too did its position vis a vis the state's governance. Although it is a private, non-profit organization, it is state-funded and reports organizationally to a cabinet secretary. Since its inception, it has reported first to the Secretary of Education, then to Commerce and Trade, and most recently to the Secretary of Technology. Its programs that fund research have shifted gradually towards projects that are closer to commercialization or that support the deployment of technologies, while its research center funding, an early focus, has been cut back due to funding constraints.

In the mid-1990s, the state further focused its economic development efforts through the creation of the Virginia Economic Development Partnership (VEDP). While Virginia's colleges and universities play a vital role in economic development and while there are regional successes for which colleges and universities played a large and significant role, there has not been a coordinated effort by which colleges and universities support the economic development efforts of the state. The mission of VEDP is:

***to enhance the quality of life and raise the standard of living for all Virginians, in collaboration with Virginia communities, through aggressive business recruitment, expansion assistance, and trade development, thereby expanding the tax base and creating higher-income employment opportunities.***<sup>39</sup>

A more recent attempt at systemic coordination comes from the creation of the Virginia Research and Technology Advisory Commission (VRTAC) in 2000. The mission of VRTAC is:

***to advise the Governor on appropriate research and technology strategies for the Commonwealth with emphasis on policy recommendations that will enhance the global competitive advantage of both research institutions and technology-based commercial endeavors within the Commonwealth.***<sup>40</sup>

VRTAC, still new in its existence, attempts to bring parties from government, business and industry, and higher education together to resolve some of the impediments to advancing research in Virginia. These developments clearly signal a desire for research and development to thrive in the Commonwealth. However, the real challenge is developing a plan of action that utilizes these structures to advance the system.

## **FINDING 7**

**The lack of state policies that support and foster academic research has hindered the ability of Virginia institutions to advance their research efforts.**

## COMPETING WITH THE NATION'S TOP RESEARCH STATES

By comparison, several states have undertaken concerted efforts to develop strategies for advancing research agendas. Probably the most visible and widely recognized efforts have been North Carolina's Research Triangle Park, created in 1958, and California's Silicon Valley, which grew out of investments dating as far back as the late 1930s. Although these efforts have evolved quite differently, they have similar characteristics that have contributed to their success: long-term vision, significant investments, and collaborative research efforts among co-located institutions, agencies, and businesses.

### Research Initiatives in Other States

More recent initiatives in other states also emulate these characteristics. Most notably, California, Florida, Georgia, Michigan, New York, Ohio, Pennsylvania, and Texas have endorsed major research initiatives, which may emerge as the "Triangle Park" or Silicon Valley of the next generation. An overview of these efforts is provided below based on data compiled by the State Science and Technology Institute ([www.ssti.org](http://www.ssti.org)).

## CALIFORNIA

California has pledged \$100 million in state support to create four *Institutes for Science and Innovation* involving numerous campuses of the University of California as well as business and industry. The Centers include:

- ***California Institute for Bioengineering, Biotechnology & Quantitative Biomedical Research***, which seeks to advance scientific understanding of human health by partnering quantitative sciences with biomedical research;
- ***California Nanosystems Institute***, which will facilitate the multidisciplinary efforts of developing and advancing nanotechnology;
- ***California Institute for Telecommunications and Information Technology***, which seeks to expand California's on-going research in this area to make anytime/anywhere information technology services more universal; and
- ***Center for Information Technology Research in the Interest of Society***, which seeks to develop applications of information technology research to address some of California's most pressing social issues (earthquake preparedness, education and health care).



## NEW YORK

The Governor of New York has proposed \$250 million as a down payment for four newly established Centers of Excellences. The Centers include:

- *Center of Excellence in Bioinformatics* (Buffalo)
- *Center of Excellence in Photonics* (Rochester)
- *Center of Excellence in Nanoelectronics* (Albany)
- *Center of Excellence in Information Technology* (Long Island)

The goals of the Centers are to support high-tech and biotech economic development and job growth efforts throughout the state and to help position the state as an international leader in these fields. The investment also will allow the state to pursue promising new biotech opportunities, including a new biotech corridor in New York City and in Rochester. The program is a public-private partnership, with the federal government having already pledged more than \$400 million for these centers.

In addition, the Governor proposed establishing the *Security Through Advanced Research and Technology*, or START, program to help colleges and universities secure federal and other high-tech research funding for the emerging national homeland security industry. New York already has a head start in this area with the development of a portable system to detect potential biological weapons, such as anthrax. Several academic institutions are seeking to create the uniform of the future for the military that will both protect soldiers from injury and shield them from detection. Governor Pataki believes the innovations resulting from this work will mean new industries and new jobs in New York State.

## MICHIGAN

In Michigan, the Governor has committed \$1 billion over the next 20 years from tobacco settlement funds to develop a *Life Sciences Corridor*. The initiative brings together the University of Michigan, Michigan State University, Wayne State University, and the Van Andel Institute, along with business and industry, to advance basic research, develop emerging technology for application in the biotechnology industry, and support start-up companies. According to the Michigan Economic Development Corporation, the Life Sciences Corridor is populated by more than 250 companies and four research universities. The state spends over \$2 billion a year in R&D and generates more than \$18 billion a year in the sale of life sciences products. The *Life Sciences Corridor* is an effort to build upon the state's success in this area.

## PENNSYLVANIA

In April 2002, Governor Schweiker officially launched Pennsylvania's *Life Sciences Greenhouse*, an historic initiative to be spread among three regions of the state: Southeast, Southwest and Central Pennsylvania. The Governor announced that the state will provide \$100 million through tobacco settlement funds as seed money for the program, with approximately \$33 million allocated for each region.

Pennsylvania's *Life Sciences Greenhouse* is designed to build on biotechnology research at Pennsylvania's top universities. The initiative is expected to create 4,400 new jobs, attract or create 100 new biotechnology companies, and leverage more than \$150 million in private capital over the next five years. The Pennsylvania *Life Sciences Greenhouse* seeks to replicate the success of the Pittsburgh Digital Greenhouse, launched by former Governor Tom Ridge in 1999.

## GEORGIA

Georgia has taken another approach, establishing the *Georgia Research Alliance* (GRA) in 1990, to bring together the state's six research universities, industry, and state government. GRA fosters economic development by leveraging the state's academic research. GRA has created "technology development centers" which target collaborative research in fields like communications technology, environmental technology, and biotechnology. Between 1990 and 1999, the state invested \$242 million in university research. This funding has been matched by \$65 million in private support and has helped attract over \$600 million in additional sponsored research.

## FLORIDA

In April 2002, Governor Bush outlined his proposal to increase technology research at Florida's universities and diversify the state's economy by stimulating the state's high-tech job sector. The legislation, sponsored by both legislative chambers, would provide \$100 million to create *Centers of Excellence* at state universities and recruit world-class professionals in the high-tech sectors to Florida. The legislation also calls for the Florida Research Consortium, a 12-member panel, to establish the criteria for evaluating the proposals for creating several university-based Centers of Excellence. The Florida Board of Education is expected approve a plan by November 15, 2002.

## OHIO

In February 2002, Governor Taft announced the *Third Frontier Project*, the state's largest commitment ever to expand Ohio's high-tech research capabilities and promoting start-up companies to build high-wage jobs for generations to come. The *Third Frontier Project* is designed to make Ohio a leader in high-tech, high-paying jobs through the following investments:

- Committing \$500 million over the next 10 years through the *Technology Action Fund* and the *Biomedical Research and Technology Transfer Fund*.
- Proposing a new, 10-year, \$500 million capital improvement program to improve research facilities. These funds will finance buildings and provide equipment for globally competitive centers of innovation that will be named after the Wright Brothers.
- Initiating a \$500 million bond program to provide much-needed resources to recruit world-class researchers and bring state-of-the-art products to market.
- Creating a \$100 million *Innovation Ohio Fund* to help finance targeted industries with high-growth, high-wage potential consistent with regional priorities. The fund will support advanced manufacturing technologies to help existing industries become more productive, competitive and profitable.

Through the *Third Frontier Project*, additional federal and private sector support are expected to boost the total investment to more than \$6 billion, and make Ohio a leader in high-tech, high-wage jobs over the next decade.

## TEXAS

In January 2002, Governor Perry announced the formation of the *Governor's Council on Science and Biotechnology Development*. The Council will work to create a seamless system of innovation from the laboratory to the marketplace in the rapidly developing areas of biotechnology -- including biopharmaceutical development, bioinformatics, genomics and nanotechnology. The mission of the Council is to bring more research dollars to Texas higher education institutions, encourage university researchers to get products that advance the quality of life to the market, and create biotechnology jobs - and growing companies - across Texas.

Among its responsibilities, Governor Perry asked the Council to identify ways institutions of higher learning can coordinate efforts to attract federal research funds. The Council will also develop a strategy to increase research and development expenditures in this state, including both private and public funds.

The 2001 Texas legislation provided more than \$800 million for science, engineering, research, and commercialization activities, becoming the most supportive legislation to science, research and tech-based economic development in recent years for the state. Of the total funding, \$385 million is for research infrastructure, \$45 million is committed to commercialization and seed financing, nearly \$150 million is for university and life science research, and more than \$300 million is for college scholarships. This initiative also authorizes the create of university commercialization centers, a series of tax credits, and \$20 million for a biotech park.

### Planning Efforts in Other States

In addition to widespread investments in research, two states – Maryland and North Carolina – are working on strategic planning efforts in this area.

#### MARYLAND

The Office of Information Technology is currently drafting a revised Statewide IT Master Plan, which will be available by June 1, 2002. In addition, the Maryland Technology Development Corporation, established by the legislation in 1998, recently completed a study on Maryland Incubator Impact — a first-of-its-kind study for the state by measuring the economic impact of Maryland's six public- and university-related high-tech business incubators on the state's economy. The study results show Maryland's incubators are a significant economic boom to the state, estimating that incubator tenants and graduates generate between \$184 and \$530 million in gross state product and between \$31 and \$96 million in taxes annually.

#### NORTH CAROLINA

In 2000, North Carolina joined a growing handful of states and regions that have completed innovation assessments or report cards to aid in the development and implementation of state's science and technology policies. The initiative is called *Vision 2030: Science & Technology Driving North Carolina into the New Economy*.

The *Vision 2030 Project* was a 15-month initiative involving more than 800 people and encompassing several studies, assessments, conferences, task forces, surveys, and focus groups. The goal of the project was both to educate and challenge North Carolinians "to begin building the science and technology-based platforms needed to support North Carolina's economy in the 21<sup>st</sup> century." The Innovation Index documents recent trends across more than 50 specific measures in 26 indicators across five categories: performance measurement outcomes, economic structure, innovation outcomes, innovation inputs, and preparation. For each measure, North Carolina is compared with the states of Georgia, Massachusetts, Michigan, Pennsylvania, Texas and Virginia. The state's new S&T strategic plan outlines 11 recommendations, each with several specific action items.

## 2002 Selected CTRF Awards

### **VIRGINIA BIOINFORMATICS CONSORTIUM**

Provides funding for researchers at GMU, UVA, VCU, and VT to work collaboratively on groundbreaking study and development in the field of bioinformatics -- a cutting edge field of study that uses the newest tools to understand life at the molecular level. Promotes interaction among the institutions, allowing them to share data more easily, collaborate in data analysis, and reduce duplication of effort.

### **CANCER GENOMICS AND DEVELOPMENT OF DIAGNOSTIC TOOLS AND THERAPIES**

Supports joint research at VCU and GMU, in cooperation with Inova Health Systems, to explore the role genes play in cancer. The research will help develop more cost-effective means of diagnosing and treating cancer.

### **HIGH PERFORMANCE MANUFACTURING CENTER**

Supports efforts at VT, JMU, VSU, and CWM to partner with manufacturing firms in establishing the Center for High Performance Manufacturing. Manufacturing is one of the most important segments of Virginia's economy, accounting for more than 407,000 jobs and annual shipments of \$6.6 billion.

Source: Virginia Department of Planning and budget, *CTRF First Quarterly Report*, October 2001.

State policymakers and those seeking to strengthen Virginia's R&D activities stand to gain from reviewing these efforts and those in other states nationwide. Examining such initiatives can provide useful information and insights as Virginia strives to move forward in advancing research activities.

### **Recent Efforts in Virginia**

In Virginia, beyond the recent activities of VRTAC, CIT and others, the Governor and General Assembly recently created the Commonwealth Technology Research Fund to focus limited state funds on critical growth areas in R&D. Established during the 2000 General Assembly session, CTRF was developed as a mechanism to leverage federal and private research support through strategic state investments at Virginia's public institutions.

The CTRF has three programs through which it awards funding to support R&D at Virginia's institutions:

1. ***Strategic Academic Enhancement:*** This program provides state support to strong academic departments that have the potential to become world-class research entities. Awards are typically made to assist institutions in recruiting high caliber faculty, acquiring specialized equipment, modernizing existing laboratory facilities, supporting graduating research assistants, or other related activities.
2. ***Matching Funds:*** Through this program, the Commonwealth commits matching funds for institutions seeking federal or private support for specific research projects. In many instances, state matching funds are a requirement of federal or private grant programs, and signal to grant makers that the Commonwealth is committed to ensuring the success of the proposed project.
3. ***Industry Inducement:*** This program provides funding to institutions seeking to upgrade their research capacity in order to attract specific companies to locate in Virginia or expand their existing operations in Virginia.<sup>41</sup>

To date, the CTRF program has committed \$25.9 million over three years to support 12 programs at Virginia's higher education institutions. Despite the initial success of this program in fostering collaboration and increased industry involvement, the state's current economic and budget situation will limit the ability of the CTRF over the next few years to make future commitments for these types of projects. In addition, if the program is going to assist institutions in attracting federal funding, the program's priority research areas may need to be more focused. Finally, even with the preliminary successes of this program, the state's annual investments pale in comparison to the major investments being made in other states.

### **FINDING 8**

**Most successful state R&D initiatives share similar characteristics:**

- **Focused area(s) of research**
- **Long-term and sustained investments in research activities**
- **Collaborative efforts among higher education, government, business and industry**

### **ADVANCING HIGHER EDUCATION RESEARCH IN VIRGINIA**

While Virginia's research enterprise places it among the top third of states nationally, there are several indications that Virginia is, at best, not recognizing its full potential in this arena, and at worst, not keeping pace with the top echelon of research states in the country. Without a strong R&D effort, Virginia undoubtedly will limit its ability to advance the state's economic development and improve the well being of its citizens.

Financial investments alone, however, will not ensure world-class research in the Commonwealth. Rather, if Virginia is to advance its research efforts, particularly in higher education, it will require a collaborative effort among higher education, private industry and government. In the 21<sup>st</sup> century, most world-class research is no longer conducted in isolation, rather it is conducted in coordination among researchers who can leverage their individual resources, coordinate research efforts, share ideas, and jointly evaluate their findings.

In addition, the Commonwealth should re-evaluate its funding policies to ensure that investments are being made in the most strategic manner possible. Over the past several decades, state support for R&D activities in the Commonwealth has been



scattered across multiple state agencies and institutions, directed to special projects, or appropriated for unique programs without sufficient coordination or consideration of the state's overall research needs, strengths, and opportunities. If Virginia is to build upon its research infrastructure, it must identify opportunities to invest in research strategically and in a manner that targets research in fields that hold promise for Virginia and its citizens. Further it must re-evaluate its policies to ensure that institutions' research efforts are not being unnecessarily inhibited. Developing the state's academic research capabilities also will require clearly articulated goals and measurable outcomes that resonate with state taxpayers, private industry, federal agencies, and other external sponsors.

As part of this vision, Virginia must not only address today's research and technology needs, but also be able to anticipate future research needs or growing areas of expertise. According to Michael Crow, Vice Provost at Columbia University, many research universities nationally are struggling to keep pace – building their research programs in areas such as microelectronics, biotechnology, advanced materials, telecommunications, robotics, aircraft manufacturing and computer hardware and software. While these issue areas may all be critical in the short run, Crow suggests that the research fields of the future will likely be in areas such as nanotechnology, biomimicry, biomaterials, bioelectronics, biocomputing, artificial intelligence, knowledge management, planetary management, and green power technologies.<sup>42</sup>

Whether the national research agenda moves in this direction is likely a subject for debate. Yet, this point remains clear. To sustain and advance a research agenda in the Commonwealth, Virginia will need to plan and invest today in order to develop the research of tomorrow. Likewise, the Commonwealth must develop a long-term commitment to research that is supported by a vision for research that resonates widely among Virginians and demonstrates a clear impact on their lives.

Toward that end, SCHEV pledges its full support to help increase the level of R&D at Virginia's colleges and universities through its creation of the *2003 Systemwide Strategic Plan for Virginia Higher Education*. This statutorily required document will be completed by SCHEV in time for use by the Commonwealth's policymakers and other research stakeholders in the 2003 General Assembly Session.

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## ENDNOTES

- <sup>1</sup> National Science Foundation, *National Patterns of R&D Resources – 2000 Data Update*, Table 6.
- <sup>2</sup> National Science Foundation, *Science and Engineering Indicators – 2000*, Chapter 6, June 2000.
- <sup>3</sup> National Science Foundation, *National Patterns of R&D Resources – 2000 Data Update*, Table 6.
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- <sup>5</sup> Ibid.
- <sup>6</sup> National Academy of Engineering. *Greatest Engineering Achievements of the 20<sup>th</sup> Century*, February 22, 2000.
- <sup>7</sup> United States Government Printing Office, *Analytical Perspectives: Budget of the United State Government – Fiscal Year 2003*, 159.
- <sup>8</sup> National Science Foundation, *National Patterns of R&D Resources – 2000 Data Update*, Table 6.
- <sup>9</sup> Ibid.
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- <sup>12</sup> Ibid.
- <sup>13</sup> National Science Foundation, *National Patterns of R&D Resources – 2000 Data Update*.
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- <sup>15</sup> National Science Foundation, *Academic Research and Development Expenditures – 2000 Early Release Tables*, December 2001.
- <sup>16</sup> Ibid.
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- <sup>18</sup> Ibid.
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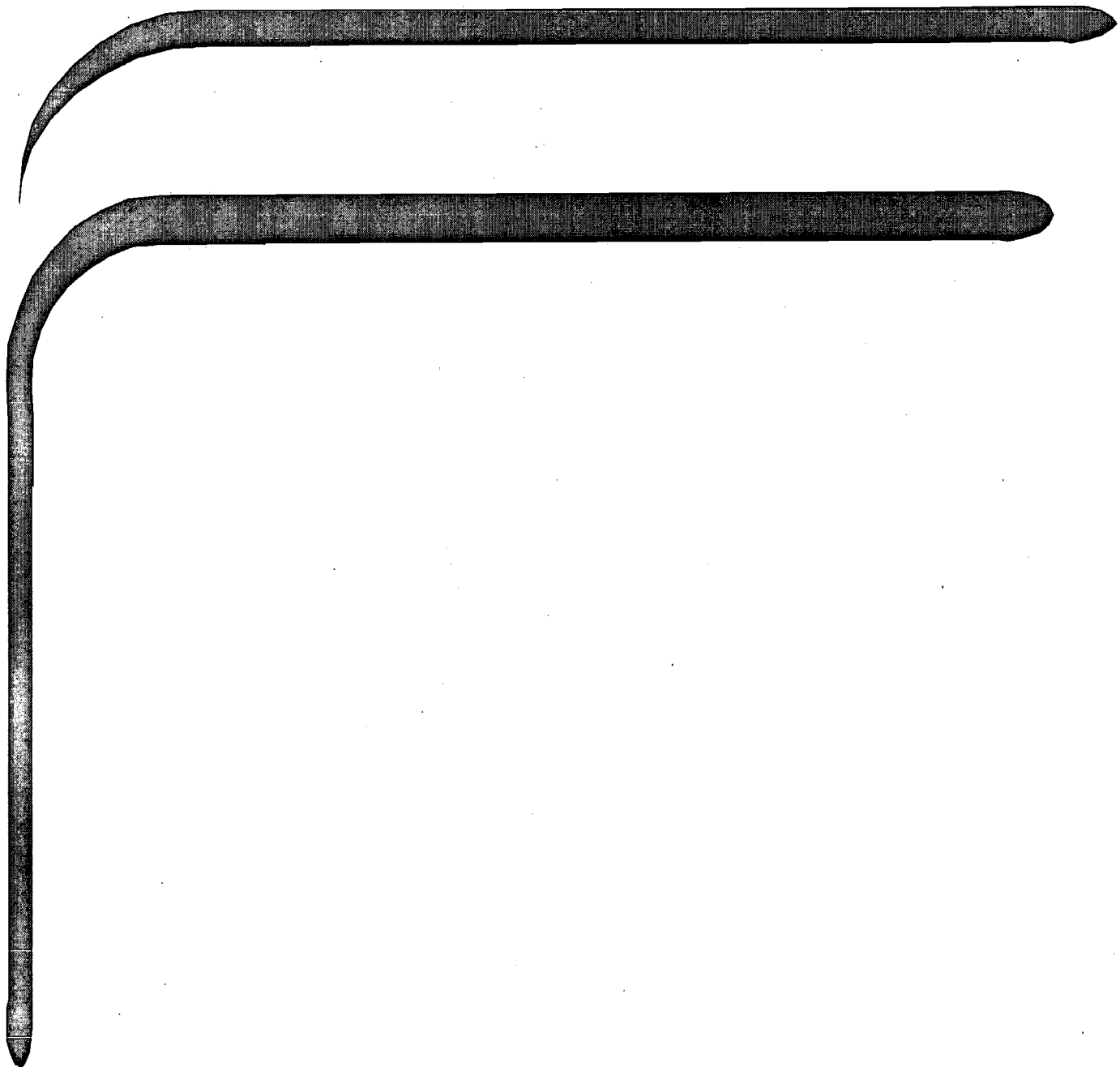
## ACKNOWLEDGEMENTS

This report is the result of collaboration and coordination beyond and within SCHEV. It reflects SCHEV's initiative not only to compile much of the national data on this important public policy issue into a single, convenient place, but also capture the insights, comments and recommendations of many talented individuals from Virginia public colleges and universities, the Virginia Research and Technology Advisory Committee, the Virginia Department of Planning and Budget, the members of the State Council of Higher Education for Virginia (SCHEV), and others.

SCHEV professional staff members Nancy Cooley, Tod Massa, G. Paul Nardo, Phyllis Palmiero, and Amy Sebring were catalysts in providing the impetus and direction for the development of this publication. Amy Sebring and G. Paul Nardo prepared the report, with research provided jointly by Finance Policy staff members Yan Zheng and Amy Sebring. Other professional staff contributors include Dan Hix, Fletcher Mangum, and Fran Bradford.

We also would like to acknowledge Judy Heiman, from the Virginia Department of Planning and Budget, for her input on this project, as well as the invaluable suggestions and research highlights provided by so many institutional faculty and administrators whose aggregate number is too great for us to name each individually.

SCHEV is grateful for all of the assistance it received in preparing this report. We hope its contents prove meaningful, and above all, useful to Virginia policymakers and all who share SCHEV's desire to increase the level of research and development at Virginia's colleges and universities.



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