Updated Economic Benefits of the New Jersey Stem Cell Capital Projects and Research Bond Acts

Prepared for:

New Jersey Senate President Richard J. Codey

by

Dr. Joseph J. Seneca
University Professor

Will Irving
Research Associate

Edward J. Bloustein School of Planning and Public Policy
Rutgers, The State University of New Jersey

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Edward J. Bloustein School
of Planning and Public Policy

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Acknowledgement

In 2004, Governor Richard J. Codey requested an economic analysis of the proposed New Jersey stem cell research initiative. A report providing that analysis was submitted to Governor Codey in October 2005. Since then, the stem cell initiative has expanded with respect to both the capital and research commitments of the state. Accordingly, Senate President Richard J. Codey requested an update of the economic analysis in order to reflect the new elements of the initiative. The authors wish to thank him for the opportunity to update our previous report. Informed public opinion and open debate concerning important public policy issues are vital requirements for responsible and effective government. We are pleased to provide this report to contribute to that process.

EXECUTIVE SUMMARY

This report is an update of the analysis of the economic benefits of the New Jersey stem cell research initiative submitted by the Edward J. Bloustein School of Planning and Public Policy at Rutgers University to Governor Richard J. Codey in October of 2005. Since that original report was completed, the initiative has been revised and now consists of bond acts that would authorize capital expenditures of $270 million for construction and equipping of stem cell research and other biomedical facilities and $450 million in funds for on-going stem cell research. This is $120 million more than the capital expenditures initially proposed and $220 million more than the original research expenditures.

In light of these increases, it is appropriate to revisit the original analysis and update the economic benefit estimates in accordance with the increases in public expenditures. ***Based on the revised public expenditures of $720 million, it is estimated that the stem cell research initiative will have total economic benefits in New Jersey of almost $2.2 billion, will result in the creation of almost 30,000 job-years (a job-year is equal to one job lasting one year), and will generate over $115 million in state revenues.***

The primary purpose of the update is to re-estimate those economic benefits that are likely to be directly affected by the increases in New Jersey's public expenditures on stem cell and other biomedical facilities and research. There are three main impacts that fall into this category:

- The economic and fiscal impacts on New Jersey of the public expenditures themselves;
- The impact on the retention and expansion of New Jersey's biotechnology sector resulting from the research effort spurred by the public expenditures; and
- The potential royalty payments that may accrue to the state as a result of the creation of a successful stem cell therapy.

Economic and Fiscal Impacts of Public Expenditures. The expenditure of $720 million on facilities and research will *directly* create jobs and generate related economic activity and, in turn, as subsequent rounds of expenditure follow from the initial outlays, there will be further complex, *indirect*, economic impacts throughout the state's economy and beyond. Following is a brief summary of these impacts for both the $270 million in capital expenditures and the $450 million in research outlays. Note that these impacts are *not* annual, but occur on a one-time basis over the period that the expenditures are made.

- ***Combined Impacts.*** ***It is estimated that the total of $720 million in public expenditures on facilities, equipment, and research will generate in New Jersey:***
  - ***$546.7 million in additional Gross Domestic Product (GDP)***
  - ***7,766 direct and indirect job-years (one job-year is equal to one job lasting one year)***
  - ***$475.3 million in income***
  - ***$19.7 million in state taxes***
  - ***$21.8 million in local taxes***

The individual components (for capital and research) within the above totals are:

- Capital Expenditures. It is estimated that the $270 million in expenditures on facilities and equipment will generate in New Jersey:
  - $186.5 million in additional GDP
  - 2,681 direct and indirect job-years
  - $152.7 million in income
  - $6.6 million in state taxes
  - $7.4 million in local taxes

- Research Expenditures. It is further estimated that the $450 million in research expenditures will generate in New Jersey:
  - $360.2 million in additional GDP
  - 5,085 direct and indirect job-years

- $322.6 million in income
- $13.1 million in state taxes
- $14.4 million in local taxes

Retention and Expansion of the Biotechnology and Pharmaceutical Industries. The biotechnology and pharmaceutical industries are both important parts of New Jersey's economy. With its large injection of capital, equipment and research dollars, the stem cell research initiative can enable New Jersey to stay at the forefront of these industries nationally, to remain an attractive location for scientists and businesses, and to maintain strong growth in the size of its life science business sectors. Assuming a conservative matching ratio of $1.50 in private life sciences industry investment for each $1 dollar in public expenditures provided under the stem cell initiative, and that this additional private investment continues after the public expenditures have terminated, ***it is estimated that the initiative would result in $1.6 billion in private life sciences research investments and $405 million in associated capital expenditures that would not have occurred in the absence of the public effort.*** As with the public expenditures, this $2 billion in private sector investments would have significant economic and fiscal impacts, including:

- ***$1.6 billion in additional GDP***
- ***22,062 direct and indirect job-years***
- ***$1.4 billion in income***
- ***$56.5 million in state taxes***
- ***$62.3 million in local taxes***

Intellectual Property Payments to New Jersey. The legislation establishing the $450 million in research grants specifies that if a research institution supported by these funds "realizes a financial gain or benefit," then the state will receive "a reasonable return on the investment" it has made. ***Using established estimates of drug development costs and of sales over the useful patent-life of a new drug, and applying a conservative patent royalty rate of one percent (1%), it is estimated that New Jersey could receive $39.3 million in royalty revenues from its support of stem cell research.*** This estimate is

based on an approach that allocates royalties to New Jersey based on the portion of total drug development costs that the public expenditures represent. Were the efforts funded by the stem cell initiative to result *directly and completely* in the development of a successful therapy, then the estimate of royalties would rise to $64.1 million.

Impacts of the Worldwide Stem Cell Research Effort. In addition to the economic benefits for New Jersey that will result directly from the public expenditures made as part of the stem cell initiative, the original report also estimated the economic benefits that would accrue to New Jersey as a result of the development of successful stem cell therapies anywhere in the world. These benefits were measured in terms of the value of premature deaths avoided, the savings from reducing workdays lost to illness and injury, and healthcare cost savings. Because these benefits would occur regardless of whether they resulted directly from the New Jersey initiative, the estimates of their magnitude are not contingent on the revised public expenditures in the updated initiative. These benefits are substantial and are included in this update in addition to the revised direct impact estimates. They indicate the large scale of the potential gains to New Jersey from successful development of stem cell therapies from the worldwide research effort.

It is estimated that the economic benefits to New Jersey of successful stem cell therapies to treat the six conditions examined in the report would total almost $73 billion, including:

- ***$11.3 billion in reduced medical costs***
- ***$813 million due to reductions in lost workdays***
- ***$60.7 billion in premature deaths avoided.***

INTRODUCTION

This report provides revised estimates of the economic and fiscal benefits of the New Jersey stem cell research initiative. The original study of benefits, conducted in 2005, analyzed the proposed initiative, which at that time consisted of the investment of $150 million for the construction of a stem cell research facility and $230 million in stem cell research support over a seven year period.[1] After review of the proposed initiative by the New Jersey Legislature and extensive public discussion, the initiative was expanded to provide $270 million for construction and equipment for stem cell and other biomedical facilities at several sites within the state and $450 million in stem cell research support (subject to voter approval) over a period of at least ten years.[2] Accordingly, the commitment of significant additional resources ($340 million) beyond the initial proposal, and now embodied in approved state legislation, warrants an update of the original estimates of the economic and fiscal benefits of the initiative.

AREAS OF ECONOMIC AND FISCAL BENEFIT

The initial study identified *six potential areas of economic benefit* to New Jersey associated with the stem cell research initiative. It was noted then, and it is worthy of repetition now, that all the estimates of benefits are subject to significant uncertainty due to the serendipitous nature of basic research and the still unknown answer to the question as to whether effective stem cell therapies will, in fact, be developed as a result of the worldwide stem cell research effort.

The study separated the six areas of economic benefits into two categories. One category consists of benefits that would accrue to New Jersey *independent* of the location of the research that develops effective stem cell therapies. This category has three components – reductions in health care costs, savings in work time lost, and decreases in

[1] See, "The Economic Benefits of the New Jersey Stem Cell Research Initiative," Joseph J. Seneca and Will Irving, Edward J. Bloustein School of Planning and Public Policy, Rutgers University, September, 2005, pp. 1-54, available at http://policy.rutgers.edu/news/press/stemcell.pdf. This update draws directly from that report.

[2] See http://www.njleg.state.nj.us/2006/Bills/PL06/102_.PDF and http://www.njleg.state.nj.us/2006/Bills/PL07/117_.PDF

premature deaths. We provide a review of the estimated benefits for this category in a later section of this report.

The second category consists of economic benefits to New Jersey that are *directly attributable* to the state's stem cell research initiative. This category also has three components – the economic impact of public expenditures for capital, equipment, and research, the retention and expansion of the biotechnology industry in New Jersey, and the potential payments to New Jersey from any intellectual property developed as a result of the state's research funding. This second category of benefits is a function of the magnitude of the state investment in stem cell and related biomedical research. It is this category of economic benefits that we update to reflect the new, larger state investment.

REVISED ESTIMATES OF DIRECT BENEFITS TO NEW JERSEY

The second category of benefits is sensitive to the size of the state's investment in the stem cell research initiative. Accordingly, this section provides revised estimates of the three components of potential benefits in this category.

Economic and Fiscal Impacts of Public Expenditures

The new initiative allocates $270 million in capital expenditures across five projects. The projects include stem cell research facilities and equipment, as well as facilities that support broader biomedical research, blood collection, and cancer research. The total capital outlay is $120 million above the original proposal. The five projects are:

* $150 million for stem cell research facilities in New Brunswick
* $50 million for biomedical research facilities in Camden
* $50 million for stem cell research facilities in Newark
* $10 million for blood collection facilities in Allendale
* $10 million for cancer research facilities in Belleville.

Table 1 provides a summary of the $270 million in outlays across the five projects and lists the proposed allocation of these expenditures between construction and equipment.[3]

Table 1

Capital Expenditures for Stem Cell and Other Biomedical Research Facilities

Facility	Construction* ($ mill.)	Equipment ($ mill.)	Total ($ mill.)
New Brunswick	100.0	50.0	150.0
Allendale	1.0	9.0	10.0
Belleville	8.5	1.5	10.0
Camden	48.0	2.0	50.0
Newark	40.0	10.0	50.0
Total	**197.5**	**72.5**	**270.0**

*Soft costs (planning, professional consultants, etc.) are classified as construction.

In addition, there will be $450 million in expenditures for stem cell research distributed over ten years. This is $220 million above the original proposal.

Expenditures of this magnitude ($720 million) will *directly* create jobs and related economic activity and, in turn, as subsequent rounds of expenditure follow from the initial outlays, there will be further complex, *indirect*, economic impacts throughout the state's economy and beyond. The extent of these impacts and their distribution over the various sectors of the state's economy will depend on the type and magnitude of the initial expenditures (construction, equipment, other capital inputs, research salaries, related research inputs) and on the complex economic relations among business sectors both within and outside of New Jersey as the incomes generated from the initial expenditures are spent in subsequent rounds of economic activity.

[3] These are the proposed allocations at this time. The actual allocations may vary as the projects proceed. Such variation will affect the economic and fiscal benefits because the impact multipliers for construction and equipment expenditures differ. However, modest changes in the allocation between construction and equipment are not likely to change the estimated benefits significantly.

We estimate the effects of all the public expenditures using the state of the art R/ECON™ Input-Output Model maintained by Professor Michael L. Lahr at the Edward J. Bloustein School of Planning and Public Policy at Rutgers University. This model contains over 500 sectors and captures the myriad economic relations among the sectors. It is capable of estimating both the total direct and indirect effects of the public expenditures described above. These expenditures are one-time and fixed in amount. Although they will occur over a number of years, their economic effects are limited to the time period when the expenditures are made.[4]

Impact of Capital Expenditures

Table 2 provides estimates of the economic and fiscal impacts of the capital expenditures of $270 million.[5]

Table 2

Economic Impacts on New Jersey of $270 Million in Capital Expenditures for Stem Cell and Other Biomedical Research Facilities (Current $)

Indicator	Construction Expenditures ($197.5 mill.)	Equipment Expenditures ($72.5 mill.)	Total Capital Expenditures ($270 mill.)
GDP ($ mill.)	149.2	37.3	186.5
Employment (job-years)	2,111	570	2,681
Direct	*1,428*	*348*	*1,776*
Indirect	*683*	*222*	*905*
Income ($ mill.)	119.6	33.1	152.7
State Taxes ($ mill.)	5.1	1.5	6.6
Local Taxes ($ mill.)	5.7	1.7	7.4

As indicated in the table, the expenditures on construction and equipment for the five stem cell and biomedical research facilities will have significant positive economic and fiscal impacts for the New Jersey. Following is a brief description of each of the impacts.

[4] It is useful to repeat here that these effects only measure the economic impacts of the expenditures *per se*. The broader, long-lasting effects of successful stem cell therapies on premature deaths avoided, reductions in workdays lost and lower public health expenditures are measured and reported separately.

[5] Note that the direct and indirect impacts are not shown separately except in the case of employment. The proportion of direct to total impacts for income and for GDP is generally close to that of employment. The input-output model does not generate separate direct and indirect estimates for tax revenues.

- **Gross Domestic Product (GDP).** It is estimated that the combined expenditures on construction and equipment for the five facilities will generate approximately ***$186.5 million in new GDP***. GDP is the total value of all newly produced final goods and services in New Jersey. It is also equivalent to the total payments made to owners of labor and capital including profits, dividends, rents and interest. It is measured and reported annually for each state by the U.S. Bureau of Economic Analysis. The model used in this analysis calculates the impact of the $270 million in estimated construction and equipment expenditures in terms of *additional* GDP for New Jersey.

- **Employment.** It is estimated that the $270 million in expenditures required for the construction and equipping of the five research facilities will generate a total of ***2,681 job-years.*** A job-year is equal to one job lasting one year, and the number of job-years generated is dependent on the total amount of expenditures and on the various business sectors in which they are made. Thus, when impacts are measured for an aggregate amount of expenditures (as in the present case), rather than on an annual basis, the job-years measure allows for the total employment generated by the expenditures to be measured regardless of when it occurs. Thus, the 2,681 job-years will be distributed over the period of time when the $270 million in expenditures is made.

  The employment impacts of the capital investments in the five facilities are divided into their direct and indirect components.

  - *Direct employment* comprises those jobs directly related to the construction and equipping of the facilities. It is estimated that the construction and equipment expenditures for the five facilities will generate ***1,776 direct job-years.*** The majority of this employment consists of construction and other jobs directly attached to the various construction sites and to provision of equipment, with some additional direct

employment occurring in other sectors that provide direct inputs to the construction process, such as manufacturing, wholesaling, and engineering services.

- *Indirect employment* results from the multiplier effect of the increase in the demand for goods and services that occurs from the spending of the compensation earned by the direct employees involved in the construction and equipping process, and from the business expenditures of contractors and other firms directly involved with the construction and equipping process. These expenditures then "ripple" through the economy, generating further positive economic effects at each round of spending. It is estimated that $270 million in total capital expenditures will generate a total of ***905 indirect job-years.***

- **Income.** Income represents the total compensation paid to workers in both the direct and induced jobs associated with the construction process. These are total, one-time, compensation amounts generated over the period of construction and equipping of the facilities. It is estimated that the 2,681 job-years generated by the $270 million in capital expenditures will earn a total of ***$152.7 million in income.*** This implies an average income of approximately $56,956 per job-year for the combined direct and indirect employment.

- **State Taxes.** It is estimated that the $270 million in capital expenditures will generate ***state tax revenues of $6.6 million.*** State taxes generated by the capital expenditures include the personal income tax, sales tax, state business taxes, various excise taxes and other state levies paid by both the employees in the direct and indirect jobs generated during the construction and equipping of the facilities, by the various firms involved in the construction and equipping process, and by the indirect business activity generated by the multiple rounds of spending that occur after the initial expenditures are made.

- **Local Taxes.** It is estimated that the capital expenditures for the five research facilities will generate a total of ***$7.4 million in local tax revenues.*** Local taxes associated with the construction process consist primarily of additional property taxes generated by the increases to both the residential and commercial property tax bases from the economic activity of the construction process.[6]

Impact of Research Expenditures

Table 3 provides the estimated economic impacts of the $450 million in research expenditures that would be authorized by voter approval of the bond issue to support stem cell research. Thus, these impacts represent the total estimated aggregate effects that would accrue *if* the entire $450 million were approved *and* allocated. If a smaller amount were allocated, the economic impacts would be reduced proportionately.

Table 3
Economic Impacts on New Jersey of
$450 Million in Expenditures for
Stem Cell Research (Current $)

Indicator	Research Expenditures ($450 mill.)
GDP ($ mill.)	360.2
Employment (job-years)	5,085
Direct	*3,268*
Indirect	*1,817*
Income ($ mill.)	322.6
State Taxes ($ mill.)	13.1
Local Taxes ($ mill.)	14.4

As with the capital expenditures, the impacts of the research outlays are measured in aggregate, with the employment measured in job-years. Thus, if the $450 million were spent evenly across a ten-year period, one-tenth of the impacts would occur in each of those years. The estimated impacts of the research expenditures are greater than those of the capital expenditures, due both to the larger amount invested ($450 million vs. $270 million) and to the higher economic multipliers associated with the research expenditures.

[6] The input-output model assumes that increases in property values are over time capitalized into property valuations, thus increasing the property tax base and generating increased local tax revenues.

That is, the per-dollar impact of the research expenditures in terms of GDP, employment, income and taxes, is greater than that of the capital expenditures due to differences in the types of expenditures required for the two activities. Thus, the expenditure of the $450 million in research funding will have significant positive economic impacts for the state, including:

- ***$360.2 million in GDP;***
- ***5,085 job-years (direct and indirect);***
- ***$332.6 million in income;***
- ***$13.1 million in state taxes; and***
- ***$14.4 million in local taxes.***

Combined Impacts of Capital and Research Expenditures

Table 4 presents the total economic impacts of the $720 million in combined capital and research expenditures.

Table 4
Combined Economic Impacts on New Jersey of $270 Million in Capital Expenditures and $450 Million in Research Expenditures for Stem Cell and Other Biomedical Research Facilities (Current $)

Indicator	Total Capital Expenditures ($270 mill.)	Research Expenditures ($450 mill.)	Total Expenditures ($720 mill.)
GDP ($ mill.)	186.5	360.2	546.7
Employment (job-years)	2,681	5,085	7,766
Direct	*1,776*	*3,268*	*5,044*
Indirect	*905*	*1,817*	*2,722*
Income ($ mill.)	152.7	322.6	475.3
State Taxes ($ mill.)	6.6	13.1	19.7
Local Taxes ($ mill.)	7.4	14.4	21.8

The last column of Table 4 provides the aggregate impacts of both the capital and the research expenditures. In all, it is estimated that, over the period in which they are made, the public expenditures will generate $546.7 million in GDP. It is also projected that the expenditures will result in the creation of 7,766 job-years earning $475.3 million in income. In addition to these economic impacts, it is estimated that the capital and

research expenditures will generate significant fiscal benefits, including $19.7 million in state taxes and $21.8 million in local taxes. It should be noted that the distribution of these impacts over time would not be uniform. The capital expenditure impacts will likely occur in the near future, as funds for construction and equipment are spent relatively quickly. In contrast, allocation of the $450 million in potential research expenditures is restricted to $45 million per year, except for carry-overs of unallocated grant capacity from prior years. Hence, allocation of these research funds will likely extend over a ten-year horizon or longer. However, some of the research expenditures could be made simultaneously with some of the capital expenditures, in which case the aggregate impacts during those years would be amplified.

Retention and Expansion of the Biotechnology and Pharmaceutical Industries

Many states and municipalities have attempted to spur economic development through the attraction and expansion of life science and biotechnology firms. The biotechnology industry, with its high value added and knowledge-based workforce, is an attractive source of new economic activity. At the same time, the economic realities of the biotechnology business sector – the relatively small size of firms, their high mortality rate, the need for significant amounts of venture capital, the uncertainties of research, and the length of time and large costs needed to bring new intellectual property through the regulatory process to commercial fruition – all constitute significant obstacles to financial success and viability.

It is important to distinguish between the biotechnology industry and the much larger and quite different pharmaceutical industry in any examination of the possible economic impact of publicly funded stem cell research. The definition of what constitutes the biotechnology industry is somewhat elusive, but a useful description is that this industry focuses on the "application of biological knowledge and techniques pertaining to molecular, cellular, and genetic processes to develop products and services."[7] The pharmaceutical industry is a much broader and more mature business

[7] See, Joseph Cortright and Heike Mayer, *Signs of Life: The Growth of the Biotechnology Centers in the U.S.,"* Brookings Institution Center on Urban and Metropolitan Policy, Washington, D.C., 2002, p. 6.

sector that certainly involves extensive research and development, but also extends to manufacturing, regulatory compliance, advertising, and marketing, typically on a worldwide scale of operations for many of its firms. In contrast, the life cycle of a (successful) biotechnology firm consists of the development of therapeutic or diagnostic intellectual property of commercial promise, often as the firm is losing money, and then the sale, licensing, or joint venture of this property with much larger pharmaceutical firms. Moreover, the biotechnology firm may have emerged initially as a spin-off from more basic research conducted in academic institutions.

Both industries – biotechnology and pharmaceuticals – have a significant presence in New Jersey, and both represent very important parts of the state's economy. The question to be examined is how the stem cell research initiative will affect these industries. Before analyzing this question, it is useful to have a sense of the size of, and the trends in, both of these business sectors.

Status and Trends in the Biotechnology and Pharmaceutical Industries

Table 5 provides data on employment levels and the number of establishments from the Quarterly Census of Employment and Wages of the U.S. Bureau of Labor Statistics for the broadly defined pharmaceutical and medicine manufacturing industry for the United States and New Jersey covering the period 1990 to 2006.[8]

The size of the industry nationally is significant. The data indicate that in 2006 the industry consisted of 2,555 establishments and employed 290,344 people. There was strong growth in the industry during the 1990s when the number of establishments increased by 45.4% (779 firms) and total employment rose by 26% (56,525 jobs). Growth has slowed in the current decade, but has remained positive with the number of establishments increasing by 2.5% (62 firms) and employment rising by 6% (16,511 jobs) between 2000 and 2006.

[8] The industry is measured by the U.S. Census Bureau according to the North American Industry Classification System (NAICS). There are four components within the pharmaceutical and medicine manufacturing industry (NAICS code 32541): medicinal and botanical products, pharmaceutical preparations, diagnostic substances, and biological products.

Table 5
Pharmaceutical Industry Profile
United States and New Jersey
1990-2006

Establishments

				Change: 1990-2000		Change: 2000-2006	
	1990	2000	2006	Number	%	Number	%
U.S.	1,714	2,493	2,555	779	45.4	62	2.5
New Jersey	163	200	247	37	22.7	47	23.5
NJ Share of U.S.	9.5	8.0	9.7				

Employment

				Change: 1990-2000		Change: 2000-2006	
	1990	2000	2006	Number	%	Number	%
U.S.	217,308	273,833	290,344	56,525	26.0	16,511	6.0
New Jersey	41,883	37,677	40,379	-4,206	-10.0	2,702	7.2
NJ Share of U.S.	19.3	13.8	13.9				

Note: Data are for NAICS sector 32541 - Pharmaceutical and Medicine Manufacturing.
Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table 5 also indicates that the pharmaceutical industry is a major economic component of the New Jersey economy, with 247 establishments employing 40,379 people in 2006. During the 1990s the sector had a mixed performance in New Jersey as the number of establishments increased by 22.7% (37 establishments), but total employment declined by 10% (4,206 jobs). These trends have improved in the current decade with the number of establishments in New Jersey up by 23.5% (47 firms) and total employment rising by 7.2% (2,702 jobs) from 2000 to 2006.

However, the state's growth in both periods lagged behind that of the nation. As a result, the share of the industry located in New Jersey as measured both by the number of establishments and total employment has declined steadily as shown in Table 5. In 1990, New Jersey had 19.3% of the nation's total employment in pharmaceutical and medicine manufacturing. By 2006, that share had fallen to 13.9%. In 1990, the state had 9.5% of all the establishments in the industry. By 2000, this share had fallen to 8%, but regained some national share (to 9.7%) by 2006.

Increased global competition, intense cost pressures, deregulation, and the growth of the pharmaceutical industry elsewhere in the nation all have combined to reduce New Jersey's once dominant position. Nevertheless, the industry remains a large and vital part of the state's economy and highly worthy of state public policy attention to retain and grow the sector.

Biotechnology firms are businesses whose primary activity is research aimed at the development of new products. These firms are not included in the pharmaceutical and medicine manufacturing categories listed in Table 5. Rather, biotechnology firms are measured separately under the NAICS professional and business services (i.e., not *manufacturing*) category of professional, scientific, and technical services. Specifically, the NAICS classification for these firms is "research and development in the life sciences" (NAICS Code 5417102).[9] However, data for these businesses in New Jersey are not available over time. Data are available for the higher level of aggregation of "physical, engineering, and biological research (NAICS Code 54171).[10] It is this sector that we believe will be most directly affected and assisted by the stem cell research initiative since it contains the dynamic, relatively small-firm, research-focused aspects of biotechnology economic activity.

Table 6 provides data on the number of establishments and total employment in the physical, engineering, and biological research industry in New Jersey and the nation from 1990 to 2006. Nationally, the industry is very sizeable. In 2006, there were 18,084 establishments employing 534,643 people. The industry grew strongly in the 1990s when the number of establishments increased by 72.6% (6,182 firms) between 1990 and 2000. Employment in the industry grew by 8.6% (35,424 jobs) over the same period. In the

[9] The definition of this industry is "establishments primarily engaged in conducting research and experimental development in medicine, health, botany, biotechnology, agricultural, fisheries, forests, pharmacy, and other life sciences including veterinary sciences." See U.S. Census Bureau, NAICS classifications (www.census.gov/epcd/ec97/def/5417102.htm).

[10] We use this definition in order to be able to conduct comparable analyses between the industry's status and performance in New Jersey relative to the nation. At the national level, approximately 45% of the establishments and employment in NAICS code 54171 are in the biological research category. Thus, this code provides an insight (albeit not a precise one) of the relative performance of the biological research industry in New Jersey and the nation.

current decade, the industry has continued to grow steadily. The number of establishments has increased by 23% (3,386 firms) from 2000 to 2006 and employment rose by a very strong 19.2% (85,967 jobs).

Table 6
Life Sciences Industry Profile
United States and New Jersey
1990-2006

Establishments

				Change: 1990-2000		Change: 2000-2006	
	1990	2000	2006	Number	%	Number	%
U.S.	8,516	14,698	18,084	6,182	72.6	3,386	23.0
New Jersey	358	556	623	198	55.3	67	12.1
NJ Share of U.S.	4.2	3.8	3.4				

Employment

				Change: 1990-2000		Change: 2000-2006	
	1990	2000	2006	Number	%	Number	%
U.S.	413,252	448,676	534,643	35,424	8.6	85,967	19.2
New Jersey	30,919	32,503	28,145	1,584	5.1	-4,358	-13.4
NJ Share of U.S.	7.5	7.2	5.3				

Note: Data are for NAICS sector 54171 - Physical, Engineering and Biological Research.
Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

For New Jersey, Table 6 indicates impressive gains during the 1990s when the number of establishments increased by 55.3% (198 firms) and employment grew by 5.1% (1,584 jobs). These were solid growth rates but below the comparable rates of growth for the nation. In the current decade, the number of establishments in New Jersey continued to rise, increasing by 12.1% (67 firms), but employment did not follow that increase. Instead, employment declined by 13.4%, (4,358 jobs). This decline in total employment during a period of very strong national job growth (19.2%) is worrisome. It also suggests that policy attention to retain and grow the industry in New Jersey is both timely and needed.[11]

[11] Again, it is important to repeat that the NAICS code definition includes research businesses beyond biological research. However, the striking difference in employment performance in the nation versus New Jersey in the current decade is likely to reflect the state's underperformance in the biological research component within the broader NAICS measure.

Table 6 also provides data for New Jersey's share of the nation's industry in terms of establishments and employment over the period. In 1990, New Jersey had 4.2% of the nation's total number of establishments in the industry and 7.5% of the country's employment. Due to New Jersey's slower growth rates during the 1990s, these shares fell to 7.2% and 3.8% respectively by 2000 and have declined further in the current decade. The absolute loss in employment in the industry in the state between 2000 and 2006 (occurring at the same time that the total number of jobs nationally grew) resulted in a sizeable decline in New Jersey's employment share to 5.3%. While this share remains significantly higher than New Jersey's share of all employment in the nation (3%), the decline in both absolute jobs and the state's employment share in the industry are a concern. The state's share of the nation's establishments also declined in this decade to 3.4% in 2006.

Estimate of Benefits of Retention and Expansion of the Biotechnology Industry

In this update of the original study we provide one possible scenario of the effects of the stem cell research initiative on the biotechnology industry in New Jersey.[12] In this scenario the New Jersey stem cell research initiative is promptly implemented and the state remains an attractive scientific location for scientists and businesses in the related biotechnology areas, and, as a result, the biotechnology industry continues on its current growth path. We assume that sales increase by 8% per year for a five-year period (2007-2011) and then decline to a 5% annual growth rate for the subsequent fourteen-year period (2012 to 2025).[13] The stem cell research initiative, with its large injection of capital, equipment, and research dollars is assumed to support this growth, and in addition, to attract additional private economic activity in the biotechnology sector. This takes the form of added private investment for both capital and research. We assume

[12] In the original study three scenarios were examined ranging from pessimistic to optimistic. The scenario used here, in keeping with the conservative approach to estimate benefits, is the middle scenario of a positive, but modest, effect of the initiative on the biotechnology industry.

[13] The growth in biotechnology sales revenues has been extraordinary (42% per year nationally from 1997 to 2002). However, such rates of growth are not likely to be sustained and therefore we use a much more conservative approach in projecting future sales. We use the period to 2025 for consistency with the time period for the estimates of population projections, the prevalence estimates, and the health care costs savings estimated previously in the original report.

three different matching ratios for each $1 in public spending ($1, $1.50 and $2).[14] Table 7 provides estimates of the magnitude of the combined state and additional private investment for stem cell research in the biotechnology industry in New Jersey over the time period of the analysis.[15]

Table 7

Public and Private Matching Investment in the Biotechnology Industry
2009-2025

Private/Public Match Ratio	Total Investment ($ bill.)
$1 to $1	2.19
$1.50 to $1	2.73
$2 to $1	3.28

Using a $1 to $1 match assumption, the cumulative investment over the 2009 to 2025 period is $2.19 billion. This total increases to $2.73 billion for a $1.50 to $1 match, and $3.28 billion for a $2 to $1 match. Taking the mid-range of $1.50 to $1 as a matching scenario results in $2.73 billion in capital, equipment and research spending. However, the impacts of the $720 million in public funding are part of the $2.73 billion in investment spending and have previously been accounted for in Table 4. Thus, this $720 million should be subtracted from the $2.73 billion. Of the remaining $2 billion in private funding, approximately $1.6 billion would go toward research and development, with an additional $405 million invested in construction and equipment.

Table 8 presents the impacts of each type of spending and the total. Together, these private investments would result in the creation of 22,062 job years and lead to an increase in GDP of approximately $1.6 billion (current dollars). The private investment

[14] The study done for the California stem cell initiative indicated that historically there has been $2.80 in private investment in research and development for each $1 in public funding. See, Economic Impact Analysis, Proposition 71, California Stem Cell Research and Cures Initiative, Analysis Group, Inc., September 14, 2004, p. 44.

[15] We assume the additional private investment in research continues after 2018 (the year the $450 million state research investment ends). The annual private investment is adjusted upward after 2018 by 4.2% annually, the historical increase in health care expenditures used throughout this report.

expenditure would also result in an additional $56.5 million in state tax revenues and $62.3 million in local taxes.

Table 8
Combined Economic Impacts on New Jersey of $405 Million in Private Sector Capital Expenditures and $1.6 Billion in Private Sector Research Expenditures for Stem Cell and Other Biomedical Research Facilities (Current $)

Indicator	Total Capital Expenditures ($405 mill.)	Research Expenditures ($1.6 bill.)	Total Expenditures ($2 bill.)
GDP ($ mill.)	270.1	1,285.9	1,556.0
Employment (job-years)	3,909	18,153	22,062
Direct	*2,567*	*11,665*	*14,232*
Indirect	*1,342*	*6,488*	*7,830*
Income ($ mill.)	223.0	1,151.8	1,374.8
State Taxes ($ mill.)	9.7	46.8	56.5
Local Taxes ($ mill.)	10.9	51.4	62.3

Intellectual Property Payments to New Jersey

The legislation establishing the $450 million in research grants specifies that if a research institution supported by these funds "realizes a financial gain or benefit" then the state will receive "a reasonable return on the investment" it has made.[16] There is great uncertainty as to whether any successful therapies (in both a clinical and commercial definition) will emerge from stem cell research. There are long time lags between research and clinical trials, the procedures for drug or therapy approval are complex, lengthy, and costly, and the intense competition within the biotechnology and pharmaceutical industries on a global basis can also quickly erode initial commercial successes. Nevertheless, it is informative to examine the revenue and royalty implications from previous successful drug therapies in order to estimate the potential intellectual property revenues New Jersey could receive from commercial success emanating from its support of stem cell research.

[16] See New Jersey P.L. 2007, Chapter 117 f.

Previous break-through biotechnology therapies are estimated to have generated $3 billion in sales per drug over the patent life.[17] Taking account of the length of time involved from the initial research to commercial fruition, we allocate the $3 billion estimate over seven years of assumed patent life for a therapy beginning in year 11 of the New Jersey project (2019). These revenues are indexed upward by 4.2% annually to reflect historical yearly price increases in health care. Annual sales revenues are assumed to start at $463.4 million in year one and increase to $1.2 billion by year seven. These revenues sum to the equivalent of the inflation adjusted $3 billion total in 2004 dollars in years 2019 through 2025.

We assume a royalty rate of return for New Jersey of 1% and we apply this rate to the annual estimates of sales over the seven years.[18] The resulting annual royalty revenues to New Jersey are then summed over the seven years of assumed useful patent life.[19] This produces an estimated royalty revenue total of $64.1 million for New Jersey as a result of one successful therapy.

However, the issue is how many commercially successful therapies will emerge from the New Jersey research effort? Past data from the industry indicate that the average cost of developing a new drug is $500 million (in 2004 dollars).[20] We assume this cost increases by 4.2% per year based on historical inflation rates in health care and we further assume that the $450 million in research grants are awarded in equal annual amounts ($45 million) over ten years beginning in 2009. For each of these seven years we divide the estimated expenditures by the current dollar value of $500 million (i.e., the development costs for one therapy) to estimate the number of therapies created in each of the seven years of research funding. These annual estimates are then summed in order to obtain a total number of .613 therapies created by the investment of $450 million in stem cell research. This estimate of .613 therapies is then multiplied by the total royalty

[17] See Analysis Group, *op. cit.,* p.81, which used estimates from SG Cowen Analyst Report, March 2004. The $3 billion estimate is in 2004 dollars.
[18] If the patent protection achieved on a specific therapy is greater than seven years, then the return will be greater than estimated here.
[19] Due to the highly competitive nature of biotechnology therapies we assume only seven-year effective patent life, the same assumption used by the Analysis Group, *op. cit.,* p. 81.
[20] See Analysis Group, *op. cit.,* p. 82, using a Frost and Sullivan Report, 21 January 2004.

revenues per therapy ($64.1 million) to obtain an estimate of $39.3 million (current dollars) in expected royalty income for New Jersey.

We conclude, as a conservative estimate, that New Jersey could receive $39.3 million in royalty revenues from its support of stem cell research. This is due to the fractional value of a successful therapy (.613) generated from the amount of state research support provided. If, however, the state research support is successful, in a most favorable case, and results in one effective therapy *directly and completely* from the research support it provides, then an upper bound would be the $64.1 million in estimated royalty revenues from a single successful therapy. Both numbers estimated here are based on an assumed 1% royalty rate for New Jersey as a "reasonable return on investment" as specified in the legislation. If, in negotiation with the State Treasurer to determine a "reasonable return" the rate agreed upon is higher than 1%, then the return to the state estimated here will increase proportionally.

Finally, it is important to note that the introduction of a successful therapy may raise total health care costs in New Jersey, in part due to the very same payment of royalties on the sales revenues derived from the new intellectual property. This increase in costs may reduce the health care savings to New Jersey of new therapies. However, the royalties would be earned on a national (or international) basis on all sales beyond New Jersey and this would work to offset any increase in New Jersey's health care costs directly attributed to the new therapy.

Summary of Updated Direct Benefits to New Jersey

Tables 9A to 9C provide a summary of all three components of benefits attributable to the new, enlarged $720 million state investment in stem cell and related biomedical research. Over the period analyzed, New Jersey's Gross Domestic Product (GDP) will increase by an estimated $2.1 billion and state and local taxes revenues paid by households will rise by $90.2 million (Table 9A). The total increase in economic

activity (GDP *plus* state and local tax revenues paid by households) will exceed $2.2 billion.[21]

Table 9A
Total Economic Benefits Attributable to Public Expenditures

Impact Category	GDP ($ mill.)	State and Local Taxes Paid by Households ($ mill.)	Total ($ mill.)
Public Expenditures	546.7	23.1	569.8
Retention and Expansion of the Biotech Sector (Private Investment)	1,556.0	67.1	1,623.1
Total	**2,102.7**	**90.2**	**2,192.9**

Table 9B

Total Employment Attributable to Public Expenditures

Impact Category	Job-Years
Public Expenditures	7,766
Retention and Expansion of the Biotech Sector (Private Investment)	22,062
Total	**29,828**

Table 9C

Total State Revenue Attributable to Public Expenditures

Impact Category	Amount ($ mill.)
State Taxes	76.2
Patent Royalties	39.3
Total	**115.5**

[21] The R/ECON™ Input-Output Model provides separate estimates of the taxes paid by businesses and those paid by households. These estimates are not shown in earlier impact tables, but are presented in aggregate in Table 9A. Taxes paid by households are added to GDP for a measure of total economic activity. Business taxes are already included in the GDP measure.

Employment in New Jersey will increase by 29,828 job-years distributed over the time of the period of the analysis. Most of these job-years are associated with the retention and expansion of the biotechnology sector caused by the public investments and the subsequent matching private investment. Given that private research expenditures are expected to continue beyond the period examined, some significant share of these jobs will be permanent (i.e., they will exist as long as the private expenditures induced by, and attracted to, the public investment continue).

BENEFITS FROM THE WORLDWIDE STEM CELL RESEARCH EFFORT

Consistent with the conservative approach of the initial study, we make no revisions to the estimates for the first category of benefits. These benefits to the state will occur if effective stem cell therapies are developed anywhere in the world and made available in New Jersey. Such benefits are very substantial – approaching $73 billion over the 10-year period beginning with the introduction of successful therapies – even using the purposefully conservative methodologies of benefit estimation applied in the initial study.[22] This category contains an estimate of the central benefit of the core goal of stem cell research, namely, the value of reducing premature deaths. In addition, there will be substantial benefits from alleviating the deep human suffering and pain of the victims and their families that is now caused by the devastating diseases and injuries that potentially can be treated with stem cell therapies.[23] Table 10 provides a review of the potential benefits to New Jersey of this first category of benefits as estimated in the original study. In addition to the benefits of premature deaths avoided, there will be

[22] The study examined the prevalence of six conditions – stroke, heart attack, diabetes, Parkinson's Disease, spinal cord injury, and Alzheimer's Disease – that potentially could benefit from potential stem cell therapies. A conservative assumption of a 25% effective treatment rate was used and applied to estimates of the current and future prevalence of these conditions in the population of New Jersey. Conservative estimates of the savings in incremental health costs caused by these conditions, the reduction in incremental work days lost attributable to these conditions, and the dollar value of a premature death avoided (measured in life-years saved) were used in order *not to overstate* the potential benefits of stem cell therapies. See, "The Economic Benefits of the New Jersey Stem Cell Initiative, *op. cit.*, pp. 18 – 31.

[23] In this effort we estimate the benefits of reducing premature deaths from the six health conditions likely to be affected by stem cell research. While this estimate is very large ($60.7 billion), it does *not* include any estimate of pain and suffering avoided. Such estimates are typically made in legal cases of wrongful death or injury. The economics of health literature, at times, uses methodologies to obtain such estimates (see, for example, "Estimating the Public Health Benefits of Proposed Air Pollution Regulations," Committee on Estimating the Health-Risk-Reduction Benefits of Proposed Air Pollution Regulations, Board on Environmental Studies and Toxicology, National Research Council of the National Academies, The National Academies Press, Washington, D.C., 2002).

substantial savings in medical costs ($11.3 billion) and in the value of fewer work days lost to illness ($813 million).

Table 10
Economic Impacts of a Successful Stem Cell Therapy on New Jersey
(Current Dollars)

Category	Value ($ mill.)
Reductions in Medical Costs	11,344
Reductions in Lost Work Time	813
Premature Deaths Avoided	60,757
Total	**72,914**

It is worth repeating that *we do not attribute these benefits specifically to the New Jersey stem cell research initiative*. Certainly, the state's initiative will both support and complement the global stem cell research effort, but it will not be the sole source of discoveries of effective stem cell therapies. Rather, our estimates of these benefits are intended to demonstrate, using conservative assumptions, what is at stake for New Jersey in terms of the potential benefits of stem cell research.

CAVEATS

While we have consistently used conservative assumptions throughout the original report and in this update, it is important to repeat several caveats. First, there is uncertainty about whether the ultimate results of stem cell research will yield effective therapies. At the same time, however, the therapies we assume here may only be a part of what, in fact, will be the ultimate portfolio of effective stem cell treatment protocols. That is, many other debilitating, painful, and costly health conditions beyond the six analyzed here may benefit from stem cell research. Second, it is important to reiterate that we do *not* attribute all the benefits estimated in the report to New Jersey's investment in stem cell research. Specifically, as noted in the previous section, the benefits from premature deaths avoided, the benefits of the reduction in work days lost due to illness an injury, and the healthcare cost savings all would occur following the discovery and widespread implementation of effective stem cell therapies from research done anywhere

in the country or the world. Rather, our estimates of these benefits are intended to demonstrate, using conservative assumptions, the very large magnitude and scale of what is at stake for New Jersey in terms of the potential benefits of stem cell research. Third, we do not discount the stream of benefits and costs of the investment expenditures. All estimates are presented in current dollar values for each year of the various periods analyzed for the several components of benefits. Fourth, we do not estimate the increase in health costs that may be attributable to effective stem cell therapies. However, any increase would have to be considered in terms of the significant reductions in the large and recurring health costs currently associated with the six conditions analyzed. Finally, we do not measure the life-cycle costs of the borrowing of $720 million in capital markets to finance the public investment.

CONCLUSION[24]

It is appropriate to conclude this report with comments about New Jersey's role and responsibilities in science and technology. Our state has always been in the forefront of innovation and discovery. The creative genius of Thomas Edison, beginning with his tinkering in his New Jersey workshop, led over the course of a lifetime of scientific research and discovery to fundamental innovations that brought enormous improvements in the daily lives of people throughout the nation and world. Edison's innovations also created new industries and new jobs on a very large scale. Guglielmo Marconi set up the nation's first site for the transmission and reception of wireless messages at Twin Lights, New Jersey, linking the country to the world with a new technology and placing the state in the forefront of what would become the telecommunications industry. Rutgers University Professor Selman Waksman and his student Albert Schatz's explorations into soil bacteria led to the development of streptomycin, substantial reductions in tuberculosis throughout the world, and the alleviation of the severe and devastating effects of this scourge. The pharmaceutical and telecommunications industries that began, grew, and thrived in New Jersey were, and are, based on scientific research and innovation. These industries have led to profound improvements in how we live and how

[24] This conclusion is taken from the original report, *op. cit.*, pp. 44-45.

well we live, with accompanying large increases in income, employment, and state resources.

While the private market, in pursuit of profit, can lead to major innovations and subsequent improvements in the quality of life, public investment in basic scientific research, and especially in research that can improve the human condition and alleviate suffering, is also an appropriate and noble responsibility of government. In the case of stem cell research, New Jersey has the opportunity to affirm its scientific legacy and participate as a full partner in this worldwide work that has such promise to raise the quality of life for so many.